



Europäisches Patentamt  
European Patent Office  
Office européen des brevets

(11) Publication number:

0 101 266  
A2

By Express Mail  
No. EM49417065US

(12)

## EUROPEAN PATENT APPLICATION

(21) Application number: 83304532.1

(51) Int. Cl. 3: B 41 M 5/24

(22) Date of filing: 05.08.83.

B 41 M 5/26, B 41 C 1/10  
B 41 N 1/14

(30) Priority: 09.08.82 US. 406628;  
09.08.82 US. 406699;  
09.08.82 US. 406700;  
09.08.82 US. 407001

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(43) Date of publication of application:  
22.02.84 Bulletin 84/8

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(64) Designated Contracting States:  
AT BE CH DE FR GB IT LI LU NL SE

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(54) Printing method and apparatus:

(57) A printing system incorporates a re-usable image-carrying printing surface. A material which forms a thin hydrophobic layer is arranged by various techniques over a substantially hydrophilic printing surface in a configuration which defines the desired latent image in terms of exposed, contiguous hydrophilic and hydrophobic areas. Depending upon the configuration of the layers, either an aqueous or oleo ink may be used to develop and print an image. If desired, the layer configuration may be replaced by a different configuration without substantial interruption to the printing process. No photo-induced chemical reaction or latent image developing steps are required at any time. In a typical apparatus, the hydrophilic surface of a printing roll (10) is cleaned (12-16) and coated with a hydrophobic material (20-24), and the hydrophobic material is physically removed from selected areas by a computer-addressable spark discharge (26-30), laser or other device to form a latent image. A fountain liquid is subsequently applied (40), followed by an ink (50), and the ink image is transferred to a substrate to be printed either directly (8) with the help of a pressure roll (6) or indirectly (8A) through an offset roll (6).

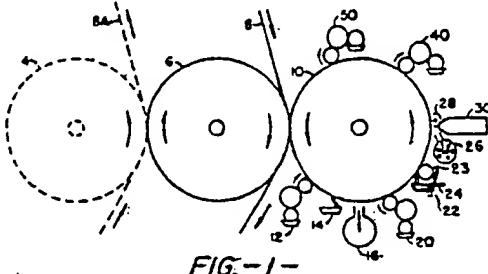


FIG. - 1 -

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## PRINTING METHOD AND APPARATUS

## 5 BACKGROUND OF THE INVENTION.

This invention relates to printing systems using a printing element on which the image is defined in terms of contiguous hydrophilic and relatively hydrophobic regions, and which is capable of serving as a printing plate or other 10 analogous source of a transferrable ink image. More specifically, this invention relates to a novel printing system comprising a non-photosensitive, reusable printing surface suitable for use in a lithographic-type or other printing system, on which an ink image may be formed, 15 refreshed, or completely reconfigured electronically, without a separate development or plate making step, without removal of the printing element, and without substantial interruption of the printing process.

In modern printing systems using printing plates such as 20 letter-press and intaglio or gravure systems, the image portions of the printing plate are defined in terms of raised or recessed areas of the plate surface which are made to carry ink. In planographic systems such as lithography, however, the image portions of the printing plate, i.e. 25 those portions of the printing plate surface intended to carry ink, are formed at substantially the same surface

level as the rest of the plate. Rather than depend upon the relative elevation of portions of the plate surface to define the ink-bearing image, planographic systems depend upon certain areas of the plate having a greater relative 5 affinity for water than is shown by the remaining areas of the plate.

In a typical lithographic printing system, the relative immiscibility of grease and water is used to define and maintain the image and non-image areas of the printing 10 plate. In standard lithographic printing systems where greasy-type or oleo inks are used, the lithographic plate is made oleophilic (grease-loving) and hydrophobic (water-hating) in image areas (i.e., those areas which will receive and transfer ink to the paper sheet or other 15 material to be printed), and hydrophilic (water-loving) in the non-image areas. These latter areas, which are in image-complementary configuration, are sometimes referred to as "lithographically blank" areas, because they normally carry or transfer no ink. So long as sufficient water is present in these lithographically blank areas, no oleo-type 20 ink will adhere to the plate in these non-image areas. By this arrangement, these hydrophilic, image-complementary areas of the plate will retain preferentially an aqueous fountain or dampening fluid applied to the plate to the 25 exclusion of the remaining portions of the plate, and will thereby allow the greasy ink applied thereafter to adhere

only to the oleophilic areas of the plate intended to carry the ink image.

Various techniques have been developed for establishing the hydrophilic and hydrophobic areas of the printing plate.

- 5      The most popular method of establishing such image-defining areas is with the aid of light sensitive materials which tend to undergo chemical reactions when exposed to actinic light. In a typical process, when using negative-imaged films, the so-called "negative" plate is covered with a
- 10     layer of a light sensitive diazo or photopolymeric formulation. Strong light energy passing through the negative film and striking the plate causes the diazo or photopolymeric formulation in the exposed or imaged areas of the plate to undergo a chemical change, e.g., to polymerize, forming thereby a hardened, hydrophobic, ink receptive area.
- 15     The non-polymerized formulation in the unexposed or image-complementary areas of the plate is removed by washing the plate surface with a solution in which only the unexposed, non-polymerized formulation is readily soluble.
- 20     These unexposed, washed areas are then treated with gum, i.e., a gum formulation containing gum arabic, carboxymethyl cellulose gum, or the like. Often, the non-polymerized formulation is washed away and the gum added in a single step. If a long wearing plate is desired, a thin film of a
- 25     gum-containing material may be rubbed onto or otherwise applied to the plate and the plate surface washed with

water, thereby causing a water insoluble layer of gum to be adsorbed onto the unexposed or image-complementary areas of the plate surface, and forming a highly hydrophilic surface which will wet readily with water, and will thereafter  
5 reject ink.

If a positive rather than a negative type film is used, the so-called "positive" plate is first sensitized with a light sensitive coating which degrades when exposed to actinic light. Exposure of the plate, via the positive  
10 film, then results in degradation of the coating in what will be the image-complementary (i.e., non-ink-carrying) portions of the image. The coated plate is chemically washed to remove the degraded areas of the coating. The plate is then baked to harden the coating in the image  
15 (i.e., ink-carrying) areas, and coated with a gum-containing material such as gum arabic or the like, as is done with the "negative" plate discussed above.

Systems using light sensitive materials customarily require the preparation of a photographically-generated film  
20 negative or positive transparency, as well as the careful projection of the image carried by the transparency onto the light sensitive surface of the plate. In certain systems, e.g., in so-called photo-direct systems, a plate may be exposed directly by the original copy without the need for  
25 an intermediate film transparency. In either case, however, it is usually necessary that the resulting plate be

developed and rinsed and a finishing solution usually must be applied.

- Electrostatic systems for generating a lithographic plate may be based on use of either a hydrophilic or a hydrophobic toner material. If, for example, a hydrophobic toner material is used, a plate surface comprising a photoconductive material which is hydrophilic is given a uniform electrical charge prior to being exposed to light striking the plate in image-complementary configuration.
- The light causes neutralization of the electrical charge in the illuminated areas of the plate. To develop the plate, a toner carrying a charge opposite to that of the remaining charged areas of the plate is then applied and made to stick to the plate surface. After fusing, the toned areas become hydrophobic, while the untoned areas remain hydrophilic.
- Use of a hydrophilic toner material employs analogous process steps with an initially hydrophobic plate surface.

The lithographic-type plates produced by the various techniques discussed above, as used in printing presses and processes of conventional design, generally exhibit substantial deficiencies which are well known and commonly encountered in the printing industry. Representative of these deficiencies are the following:

- 1) inability to generate a high quality lithographic-type printing plate without film preparation steps or without elaborate plate exposure and development procedures;

- 2) inability to reconfigure completely the image being printed by the plate without substantial interruption of the printing process or substitution of a second plate carrying the desired reconfigured image;
- 5       3) inability to refresh or renew the oleophilic and hydrophilic areas of the image carried by the printing plate without substantial interruption of the printing process;
- 10      4) inability to correct minor deficiencies in the image being printed by the plate - for example, those deficiencies caused by incomplete or unintended removal of material from the plate surface, or by foreign matter residing on the plate surface - without substantial interruption of the printing process;
- 15      5) inability to correct substantial registration errors in the plate without re-plating;
- 20      6) inability to print a continuously repeating pattern on a web substrate using a rotary-type press without a gap or seam between plate image pattern repeats and without the use of additional plates or ink heads;
- 25      7) inability to print a pattern wherein the repeat length is greater than, or wherein the repeat length will not integrally divide into, the plate length or circumference of the plate roll;
- 8) inability to eliminate roll shock, i.e., the mechanical interaction between the respective gaps of the plate and blanket rolls in rotary offset printing methods, which limits press speeds;

- 9) inability to proof conveniently a freshly generated plate under true production conditions, using production inks, papers, etc.;
- 10) inability to store the equivalent of a large library of printing plates for short or periodic printing runs without substantial maintenance and inventory costs;
- 11) inability to generate a lithographic-type printing plate, which requires no separate developing process, or print imagery using a lithographic-type printing process,
- 10 directly from a source of electronically-generated images such as a digital computer.

Attempts to overcome these and other deficiencies of existing systems generally have met with only limited success. Disclosed herein is a printing system employing a reusable printing plate which overcomes all of the above-listed deficiencies, as well as others associated with almost all photolithographic techniques, such as halation (i.e., imperfect light exposure caused by the reflective nature of the printing plate supporting base).

20 A substantially planographic plate suitable for service in a lithographic-type printing system is described herein which is comprised of an intrinsically hydrophilic plate material which supports a thin hydrophobic layer thereon. Also described herein is a method for generating, imaging, 25 and using such a plate to print electronically generated images in various printing processes. According to the

teachings herein, a method for generating a plate for use in a lithographic-type printing system comprises coating uniformly an intrinsically hydrophilic support surface with a thin hydrophobic layer of a suitable material, then 5 selectively removing the material in a pre-determined configuration by means of an electronically addressable imaging system utilizing an electric spark discharge, a beam of electromagnetic energy (e.g., a laser beam), a beam of ionized particles, or other means. Alternatively, the 10 hydrophilic plate surface may be first coated with a thin layer of a hydrophilic protective material, for example, a gum-containing material, prior to the application and selective removal of the material forming the hydrophobic layer. As additionally taught herein, suitable material for 15 forming a hydrophobic layer may be directly, selectively applied to the plate in the desired configuration. Whether selectively removed or selectively applied, the hydrophobic layer material may be said to be arranged over the plate surface in a desired image-related configuration. These as 20 well as other developments, all of which involve a reusable, easily re-imageable ink image generation surface useful in various printing processes, are described herein. As used herein, ink image generation surface is intended to mean the surface on which the ink image corresponding to the desired 25 printed image is initially formed. This surface generally will be the surface on which a pre-ink latent image, i.e.,

an image defined in terms of adjacent hydrophilic and hydrophobic areas, is also initially formed. The term "imaging" is intended to mean the generation of this latent image, prior to the application of ink.

- 5       Described herein is a surface suitable for use, for example, as a planographic printing plate in either rotary or non-rotary printing systems wherein an electronically embodied image may be impressed directly onto the plate, without requiring the use of photosensitive materials or
- 10      coatings, or without elaborate developing steps. In addition, the disclosed surface is re-usable, in the sense that a lithographic plate, for example, when imaged and used for printing in accordance with the teachings of this invention, may be re-imaged with the same or with a totally different image without the need for replacing the plate.
- 15      In fact, an image having a length greater than (or not an integral divisor of) the circumference of the plate roll, where such roll is used, may be printed by changing the image associated with one portion of the plate roll while
- 20      another portion of the roll is transferring an ink image to an offset roll or directly to a substrate.

Throughout this discussion, the terms "printing plate" or "plate" shall be used to describe a substantially flat, planographic surface capable of recording an image defined in terms of hydrophobic and relatively hydrophilic areas; such a surface may be the ink transfer surface associated

with either a planar or curved lithographic printing plate,  
and may even be, for example, the print roll surface itself  
and not a separate, detachable entity usually associated  
with the term "plate." The printing plate may take the form  
5 of a planar surface, a cylinder, an endless belt, or other  
form. It is foreseen that the printing element as described  
herein may also comprise the printed product, e.g., the  
plate need not serve as an ink transfer surface, but as the  
printed substrate itself. In addition, other,  
10 non-planographic surfaces may be employed as well.

A method and apparatus is herein disclosed which can  
completely eliminate the costs associated with generating a  
plate using conventional photolithographic techniques, as  
well as the costs involved in maintaining a conventional  
15 plate library for short-run or periodic printing jobs. The  
necessity of replacing a plate when a sharpened, or slightly  
modified, or totally reconfigured image is desired is  
completely eliminated. The costs and limitations associated  
with having gaps in the plate used in rotary-type presses  
20 which cause a printing gap or seam in matter printed on long  
webs, as well as the mechanical shock associated with such  
plate gaps and the speed limitations such plate gaps impose,  
can be completely eliminated by imaging the roll surface as  
herein described, rather than imaging a separately attached  
25 printing plate of conventional design. Additionally, a  
series of pre-production run proofs may be generated

- inexpensively, and with the advantage that the proofs may be printed on the same machine, using the same plate, paper, inks, and many of the same press adjustments as the final production run, thereby eliminating any doubt whatsoever as to the appearance of the final printed image. Whatever adjustments are necessary to develop a satisfactory proof, regardless of their magnitude, can be made to the plate without removing the plate from the press, or having to make ready and install an entirely new plate.
- 5           The teachings herein may be used in a wide variety of printing applications, particularly where, for example, minimal costs for plate preparation, set up, storage, or inventory are desired, or where no gap or seam between plate images on a continuous printed substrate is desired.
- 10          Because of the lack of any plate gap or seam, and any corresponding mechanical shock originating therefrom, the teachings herein are also particularly suited to applications wherein high speed printing (e.g., high speed rotogravure speeds) is desired.
- 15          Because of the lack of any plate gap or seam, and any corresponding mechanical shock originating therefrom, the teachings herein are also particularly suited to applications wherein high speed printing (e.g., high speed rotogravure speeds) is desired.
- 20          Other features and advantages will become apparent from the following detailed description in which reference is made to the Figures summarized below.

#### DESCRIPTION OF DRAWINGS

- Figure 1 schematically depicts a rotary printing system using printing plate described herein is being continuously erased and re-imaged by means of an electric spark discharge
- 25

means while the plate is transferring a portion of the image onto a web substrate;

Figure 2 schematically depicts the printing system of Figure 1 wherein the plate is not being erased and 5 re-imaged, but is being used to make a series of impressions or copies on a web substrate of the existing image on the plate;

Figure 3 schematically depicts an apparatus which may be used to image a plate in accordance with the teachings 10 herein;

Figure 4 schematically depicts a printing system similar to Figure 1 in which a laser has been substituted for the electric spark discharge means;

Figure 5 schematically depicts a plate, attached to a 15 plate roll, embodying the teachings herein, as well as a mask which may be used in imaging the plate;

Figure 6 schematically depicts a stylus bar, comprised of individually addressable styli, of a type suitable for imaging printing plates herein described according to the 20 teachings herein;

Figure 7 schematically depicts a rotary lithographic-type printing system employing a control system for correctly sequencing and controlling a variety of operations directed to imaging, re-imaging, or printing an 25 image on a substrate according to the teachings herein.

Figure 8 schematically depicts the system of Figure 7 which has been modified to include a separate hydrophilic layer applicator;

Figure 9 schematically depicts a printing apparatus in  
5 which a reusable cylindrical printing screen is used.

Figure 10 schematically depicts a magnified perspective cross-section of an imaged planographic plate surface.

Figure 11 schematically depicts a magnified perspective cross-section view of a portion of a gravure roll surface  
10 which has been imaged according to the teachings herein.

Figure 12 schematically depicts a magnified perspective cross-section view of a printing screen which has been imaged according to the teachings herein.

#### DESCRIPTION OF PREFERRED EMBODIMENTS

15 In the apparatus and process depicted in Figure 1, a plate roll or cylinder 10 is continuously re-imaged with the same or a different image or pattern at the same time a substrate 8 is being printed. As suggested above, the plate may take a form other than a roll or cylinder. For example,  
20 the apparatus of Figure 1 could be modified to accommodate an endless belt having a suitable hydrophilic surface, rather than the roll shown.

The process depicted in Figure 1, which may be a lithographic process in which an oleo ink is employed, will  
25 be explained beginning with cleaning roll stack 12. Stack 12 applies a conventional cleaning solvent to the surface of

roll 10 which, in conjunction with soft doctor blade 14 and solvent drying jets 16, removes all traces of ink, fountain solution, solvent, and foreign matter, without marring the roll surface. If removal of any previously applied  
5 hydrophobic layer material is necessary, it may be removed with heat, solvents, or, perhaps most simply, by activating the imaging means to produce a totally "blank" or hydrophilic plate, as will be discussed later. Similar procedures may be employed if removal of gum is desired, as  
10 will be discussed later.

The roll surface of plate roll 10 is comprised of a material which is intrinsically substantially hydrophilic - a material having a surface which, when clean, i.e., free of significant contamination, is substantially hydrophilic.  
15 Any suitable intrinsically substantially hydrophilic material may be used in the present invention. Typical suitable hydrophilic materials include, but are not necessarily limited to, metals such as nickel, copper, tin, aluminum, stainless steel, zinc, brass, phosphor bronze, titanium, zirconium, palladium, niobium, platinum, lead, molybdenum, tantalum, tungsten, iron, and gold, as well as non-metallic materials such as an aluminum oxide/titanium dioxide composite (60%  $\text{Al}_2\text{O}_3$ , 40%  $\text{TiO}_2$ ), and mixtures thereof. While any suitable intrinsically hydrophilic  
20 material may be used with this invention, stainless steel and aluminum are particularly suitable for many  
25

applications. If, under some circumstances, the roll material chosen tends to form a relatively hydrophobic coating (e.g., a coating of airborne contaminants, etc.) upon exposure to the atmosphere, it may be desirable to coat 5 the roll surface with a layer of a suitable protective material, for example, a gum formulation containing gum arabic, carboxymethyl cellulose gum, or the like, which formulation will herein be referred to simply as "gum." Such coating is also recommended if maximum longevity of the 10 image on the roll is desired. If done immediately following the imaging process, the gum is attracted to the exposed hydrophilic areas and tends to form a protective coating over these hydrophilic areas which is itself hydrophilic, thus protecting and preserving the image and extending plate 15 wear. Alternatively, such coating may be applied prior to the application of the hydrophobic layer material, as will be discussed hereinbelow.

Applicator 20 applies a thin layer of a suitable hydrophobic layer material through the action of a roll 20 stack 20 which extends across the width of roll 10. The action of doctoring means 22, here depicted as a roll 23 preceded by a water jet wash system 24, removes excess material, and assures a thin, relatively uniform and continuous hydrophobic layer of material on the surface of 25 roll 10. Any suitable thickness of hydrophobic layer material and means or method of application may be used. In

many applications, however, a layer thickness which approaches monomolecular dimensions has been found to be quite satisfactory and is preferred from the standpoint of uniformity of application and ease of cleaning when using many of the hydrophobic layer materials suggested and discussed hereinbelow. Any method or means for applying suitable quantities of the hydrophobic layer material which results in relatively uniform and complete coverage of the roll surface, and which does not contaminate the roll surface, may be used. For example, an atomizer may be employed. A preferred applicator, however, is a roll train fed from a trough of the hydrophobic layer material, immediately followed by a water flush and contact with a doctoring roll or blade, substantially as depicted in Figures 1-4. It is generally advantageous to use application techniques which result in the application of a layer which is self-limiting in thickness, preferably approximately monomolecular in thickness.

While any suitable material may be used to form the hydrophobic layer of the plate, the material chosen preferably should meet several requirements in order to achieve the highest quality in the resulting printed image. It preferably should be a material which, when applied to the roll or plate in a thin layer, effectively renders the roll or plate substantially uniformly hydrophobic and oleophilic, by providing a hydrophobic and oleophilic layer

thereon, which exhibits a relatively large wetting angle with respect to the desired aqueous developer material used, an affinity for the type of printing ink to be used, and which is relatively durable. Equally important, it

5 preferably should be a material which has an affinity for the roll surface and which can be applied in a thin, smooth layer over the roll surface, as well as over small quantities of any contaminants or residual material which may be found thereon, without significant discontinuities or

10 open areas, thereby forming a layer which is substantially uniformly hydrophobic. Materials which can be applied in a relatively uniform, homogeneous layer have been found to be effective in providing a substantially uniformly hydrophobic layer. It has been found that a layer of hydrophobic layer

15 material having a thickness which approaches or approximates monomolecular dimensions and which appears to be adsorbed onto the surface of the roll is quite effective, and is generally preferred; for this reason, materials which readily yield such layers, for example, as the result of

20 self-limiting application techniques, are generally preferred. The descriptions which follow will speak in terms of an adsorbed layer of material. It should be understood that, while it is believed adsorbed, monomolecular layers are achieved, somewhat thicker layers

25 may actually be resulting from the techniques described herein. Under certain conditions, substantially thicker

layers may be preferred (see, e.g., tetracosane, Table I, and discussion hereinbelow). A thin layer, however, is generally easier to remove than a thicker layer, usually results in fewer problems with generation of possibly undesirable vapors, etc., and is therefore generally preferred over a thicker layer of the same material. For maximum versatility, the material may be one which does not leave a residue upon heating to temperatures of about 345°C or above. It is thought that meeting this test assures that the roll or plate coated with the material may be erased and re-imaged a large number of times without experiencing problems with residue buildup. If generation of a longer lasting image on the roll is desired, e.g., if no periodic re-imaging is to be provided, it is desirable that the material chosen be relatively unaffected by exposure to the fountain solution or ink, to the atmosphere over the time period during which the plate is to be used, or to whatever gum-containing formulation is used. It is also recommended that the material chosen be one which, after being applied to the roll, does not readily migrate, i.e., does not transfer itself either onto surfaces contacting the plate or roll surface, or into hydrophilic areas on the plate or roll surface. Unlike systems of the prior art, there is no requirement that the material be photosensitive or photo-chemically reactive, or that the material be comprised of a polymer, an oligomer, or a material which is subject to

polymerization, oligomerization, or cross-linking. Suitable polymer or oligomer-containing or cross-linkable materials, may be employed if desired, however (see, e.g., polyvinyl butyral, Table I). There is also no requirement that the  
5 material be readily dissolvable in a wash or developing solution.

A variety of materials have been found to meet these requirements. Table I lists typical examples of these materials, along with the particular solvents used in the  
10 application of these materials to the noted metal shim stock, and the contact angles observed in laboratory contact angle tests, as measured manually with an optical comparator. The measured contact angle, which corresponds to the wetting angle as defined by the Young equation, is an  
15 inverse measurement of the spreadability or wettability of a liquid - in this case, distilled water - on a solid surface - in this case, the plate surface carrying a thin layer of the material being tested. The lower the observed contact or wetting angle, the more wettable the surface is by the  
20 distilled water, and, presumably, the less suitable the material comprising the layer may be as a hydrophobic layer material for use with an aqueous fountain solution in a lithographic-type printing process. The solvent temperatures were approximately 22°C unless otherwise  
25 specified. The contact angles were observed on a section of Type 304 stainless steel shim stock which was pre-treated by

TABLE I  
SOLUTION DATA  
CONTACT ANGLE

MATERIAL	SOLUTION DATA	CONTACT ANGLE
<u>CARBOXYLIC ACIDS</u>		
Tetradecanoic Acid	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water	125°
Hexadecanoic Acid	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water	126°
Octadecanoic Acid	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water	130°
Oleic Acid	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water	98°
Isooleic Acid	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water	120°
<u>CARBOXYLIC ACID SALTS</u>		
Hexadecanoic Acid ( $\text{NH}_4^+$ )	0.1% (wt.) in Dist. Water, pH=10. (60°C)	115°
Hexadecanoic Acid ( $\text{Na}^+$ )	0.1% (wt.) in Dist. Water, pH=10. (60°C)	100°*
Hexadecanoic Acid ( $\text{K}^+$ )	0.1% (wt.) in Dist. Water, pH=10. (60°C)	120°
Octadecanoic Acid ( $\text{NH}_4^+$ )	0.1% (wt.) in Dist. Water, pH=10. (60°C)	115°
Octadecanoic Acid ( $\text{Na}^+$ )	0.1% (wt.) in Dist. Water, pH=10. (60°C)	125°*
Octadecanoic Acid ( $\text{K}^+$ )	0.1% (wt.) in Dist. Water, pH=10. (60°C)	120°
Oleic ( $\text{NH}_4^+$ )	0.1% (wt.) in Dist. Water, pH=10. (60°C)	90°
Oleic ( $\text{Na}^+$ )	0.1% (wt.) in Dist. Water, pH=10. (60°C)	69°*

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TABLE I (con't.)

MATERIAL	SOLUTION DATA	CONTACT ANGLE
<u>METAL SOAPS (WITCO)</u>		
Aluminum Stearate No. 18	0.1% (wt.) in Toluene	90°
Magnesium Stearate D	0.1% (wt.) in Toluene, (77°C)	96°*
Sodium Stearate T-1	0.1% (wt.) in Toluene, (77°C)	86°*
Calcium Stearate	0.1% (wt.) in Toluene, (110°C)	78°*
<u>ANIONIC SURFACTANTS (ROHM &amp; HAAS)</u>		
TRITON W-30 (Sodium Alkylaryl Ether Sulfate)	0.1% (wt.) in Dist. Water	70°*
TRITON QS-44 (Phosphate Ester-Acid)	0.1% (wt.) in Dist. Water	95°*
<u>HYDROCARBON WAXES</u>		
Tetracosane	Hexane	90°*
<u>ETHOXYLATED CARBOXYLIC ACIDS (GLYCO)</u>		
Pegosperse 100-0 (Oleic Acid + 2 E. O.)	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water	98°*
Pegosperse 400 DS (Diester of Stearic Acid + 8 E. O.)	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water	98°*

TABLE I (con't)  
MATERIAL      SOLUTION DATA      CONTACT ANGLE

<u>CARBOXYLIC ACID ANHYDRIDES (MILLIKEN CHEMICAL)</u>		
Octadecenyl Succinic Anhydride	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water (66°C)	88°*
Tetradecenyl Succinic Anhydride	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water (66°C)	88°*
Dodecenyl Succinic Anhydride	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water (45°C)	89°
Isomerized Dodecenyl Succinic Anhydride	0.1% (wt.) in 50/50(vol.) 2-Propanol/Dist. Water (45°C)	99°*
<u>INORGANICS</u>		
Sulfur (Elemental)	0.1% (wt.) in toluene (110°C)	69°*
<u>POLYMER (MONSANTO)</u>		
Polyvinyl Butyral (BUTVAR® B-76)	0.5% (wt.) in toluene	85°*
<u>POLYMER (ROHM &amp; HAAS)</u>		
Acrylic Resin (ACRYLOID® B-44) (in solution)	1.0% (wt.) in toluene	80°*

placement in a muffle furnace at approximately 345°C for one minute. Except where noted below, the shim was dipped quickly in the solvent containing the recited concentration of material, removed, quickly and thoroughly rinsed with 5 distilled water, and the contact angle measured. Several trials for each material were performed. Angles marked with an asterisk indicate that lower contact angles were obtained on some trials with these particular materials; it is thought these materials may be somewhat sensitive to the 10 uniformity of the application process.

In general, hexadecanoic and octadecanoic acids may be preferred over their acid salts, because, among other things, the relatively inferior solubility of these salts can make uniform application difficult.

15 The ammonium and potassium salts are particularly preferred among the preferred acid salts listed. The preferred metal soaps are all salts of stearic acid using either aluminum, magnesium, or calcium cations, and were all supplied by Witco Chemical Co., 277 Park Avenue, New York, 20 New York 10017.

The preferred anionic surfactants listed are products of Rohm & Haas, Independence Mall West, Philadelphia, Pennsylvania 19105. While the observed wetting angle of the phosphate ester was relatively high, it is thought that a 25 phosphate residue may develop if the material is repeatedly removed and reapplied, as where the printing plate is reconfigured frequently.

Tetracosane is a preferred hydrocarbon wax which was applied by dipping a shim in the hexane solution and merely allowing the hexane to evaporate. While the resulting applied layer was substantially thicker than the other materials, tetracosane still exhibited a satisfactory contact angle and is believed quite suitable for use in printing applications where a thicker layer of material would be advantageous.

The listed preferred ethoxylated carboxylic acids are products of Glyco, Inc., 51 Weaver Street, P.O. Box 700, Greenwich, Connecticut 06830.

The preferred carboxylic acid anhydrides listed are the reaction product of olefins and maleic anhydride, and are manufactured by Milliken Chemical, P.O. Box 817, Inman, South Carolina 29349.

Elemental sulfur is an example of a preferred inorganic or non-carbon containing material which may be used to form a hydrophobic layer.

Polyvinyl butyral is an example of a suitable polymeric material is preferred. The sample used is marketed under the name Butvar B-76, a product of Monsanto Plastics and Resins Co., St. Louis, Missouri 63166.

The acrylic resin ACRYLOID B-44, distributed by Rohm & Haas, Philadelphia, Pennsylvania, is another example of a preferred polymeric material.

Returning now to the features of Figure 1, roll 10 passes roll stack 22 or similar means for assuring that a thin, uniform layer of the chosen hydrophobic layer material is being applied over the entire roll surface. For purposes 5 of explanation, if roll 10 were subjected at this point in the process to applications of fountain solution and oleo ink via roll stacks 40 and 50, respectively, roll 10 would print solid ink.

In the embodiment shown, arranging the hydrophobic layer 10 material on roll 10, thereby forming a latent image, is achieved by an imaging means which removes, e.g., by ablation, selected portions of the hydrophobic layer in a desired image-complementary configuration, thereby rendering those areas relatively hydrophilic. Any suitable energy 15 means may be used as an imaging means to remove the hydrophobic layer material in the manner intended. There is no requirement that the energy means be sufficiently powerful to change the nature of the underlying roll surface. In fact, it is generally advantageous that the 20 nature of the underlying hydrophilic material remain substantially unchanged, and it is an advantage of the invention that such change is generally unnecessary. The generally preferred energy levels are therefore those levels which are sufficient to remove the necessary quantities of 25 hydrophobic layer material, without substantially affecting the hydrophilic material thereunder, excepting possible

minor pitting, etc. It is thought that, by removing portions of the hydrophobic layer, a portion of the underlying hydrophilic material is at least partially or more nearly exposed, thereby creating an area which can be wetted preferentially by an aqueous developer material such as a fountain solution or an aqueous ink. It is observed that, upon selective removal of at least portions of a hydrophobic layer which coats the underlying intrinsically hydrophilic roll surface, a latent image is generated, presumably defined by contiguous hydrophilic and hydrophobic regions respectively formed by the partially exposed portions of underlying roll surface and the intact portions of the hydrophobic layer. It should be noted that, unlike systems of the prior art, no wash step or developing step, using water, solvents, toners, or any other materials is necessary to establish this latent image on the roll surface. Additionally, it should be noted that the formation of the latent image does not depend upon any photo-induced reaction, for example polymerization, cross-linking, or indeed any kind of chemical reaction as would be used to harden, soften, or otherwise "cure" a hydrophilic or hydrophobic layer, or render such layer either soluble or insoluble during a conventional post-exposure wash step or development step, as might be commonly done in systems of the prior art.

Various energy means may be employed as the imaging means to remove portions of the hydrophobic layer material from the surface of roll 10. In the apparatus of Figure 1, a stylus array is used, such as the one depicted in Figure 5 6, although electrode configurations other than a stylus may be used. Stylus array 30 is a spaced array of individually insulated and individually computer-addressable electrodes or styli 32 which are arranged generally perpendicular to and uniformly equidistant from the electrically conductive 10 surface of roll 10, within an insulating form 34. The adjacent styli spacing and total number of wire styli are functions of the desired effective printing gauge - if relatively fine, detailed lettering is desired, a high stylus density is necessary. If stylus density is so high 15 that mutual interference between adjacent styli results and inter-stylus definition is lost, several separate, closely adjacent stylus arrays of more widely spaced styli may be used in a staggered, overlapping configuration. In place of a full-width stylus array, one or more styli may be 20 positioned in close proximity to the roll surface and sequentially traversed across the roll face as the roll is incrementally rotated, thereby allowing the roll surface to be imaged without the use of a full width array of styli depicted in Figure 6. If an imaging means which is not 25 suitably selectively addressable is used, a mask, stencil, overlay, or the like, as depicted at 36 in Figure 6 may also

be used to block selectively the unintended removal of the hydrophobic layer material; use of such a mask, interposed between the imaging means and the plate surface or the hydrophobic layer thereon, may reduce the need for direct 5 computer control by allowing use of, for example, an array of continuously energized styli or other broad coverage electrode configuration sweeping the entire image area. Such array would only remove portions of the hydrophobic layer material in areas not blocked by the mask or stencil.

10 Imaging of the coated roll surface by the embodiment depicted in Figure 1 is achieved by establishing an electrical potential of several hundred volts between the roll surface and one or more selected styli in the stylus array, thereby causing a spark discharge to occur between 15 the respective tips of the selected styli and the roll surface. The energizing electrical signals are routed to the selected individual styli in an image-related configuration. The term image-related is used to mean either an image (i.e., ink-carrying) or image-complementary 20 configuration, and merely indicates that, regardless of the type ink used, the hydrophilic and oleophilic areas of the plate are arranged in a configuration from which the desired ink image may be produced. Image configuration is generally used with an aqueous ink (the ink conforms to the 25 hydrophilic areas of the plate), while an oleo ink requires imaging of the complement of the desired ink image (the ink

is made to conform to the hydrophobic area). Figure 1 depicts use of an oleo ink; therefore, the desired image configuration is image-complementary.

The duration, polarity, and waveform of such signals may 5 be tailored to the particular application and apparatus. The source of such signals, not shown, may be a digital computer or other source of electronically-generated imagery. Generally speaking, direct current signals at moderate voltage levels (300-1000 volts) and low current 10 levels (less than 10 millamps) have been found to be satisfactory. To avoid charge accumulation on the roll surface and accompanying loss of potential, the surface of the roll or plate may have relatively low electrical resistance. Also, the polarity of the energizing signal may 15 be periodically reversed. Introduction of an inert gas in the arc region such as argon, neon, helium, or combinations thereof, by means of conduit 26 in Figure 1 or by other means, is helpful in reducing the required breakdown voltage and in minimizing electrode erosion. A gas comprising 10% 20 helium and 90% neon has been used with success. Other, more expensive spark chamber-type gases may be used as well to further reduce the voltage levels required.

Where rapid imaging of roll 10 is desired, it may be difficult to initiate the necessary electrical discharge 25 without a substantial time delay between application of the requisite voltage level and the initiation of the electrical

discharge. This is thought to be due to the lack of instantaneous availability of free electrons to initiate the avalanche condition necessary for discharge to occur. It has been found that, by "seeding" the region in which the 5 discharge is to take place with charged particles, as from a corona discharge device, as depicted at 28 in Figure 1, this time delay can be substantially reduced. An ultraviolet light source may also be employed in place of a corona discharge device.

10 The resulting imaged plate is schematically depicted in Figure 10, in a magnified perspective view, wherein roll 10 is supporting hydrophilic plate 11 on which is defined an area 100 carrying a hydrophobic layer and an area 102 which is the exposed surface of plate 11. As will be explained 15 hereinbelow, a hydrophilic protective layer may be applied directly to the surface of plate 11 in area 102, and which may optionally extend within area 100.

An alternative embodiment of this invention, employing a beam of electromagnetic energy as an energy means, is 20 schematically depicted in Figure 4. In the embodiment shown, the energy of one or more incident laser beams from laser system 60 is substituted for the spark discharge described above, these beams being modulated or otherwise allowed to selectively impinge on the layer of hydrophobic 25 layer material with sufficient energy to cause selective ablation of portions of the hydrophobic layer in the desired

image-related configuration. One or more such beams may be electronically modulated and, if necessary, traversed over the plate surface. It is foreseen that laser system 60 may be an array of closely spaced lasers, arranged in a pattern analogous to the electrical styli discussed above. As before, no photo-induced chemical reaction is believed to contribute in any significant way in this imaging process.

Examples VIII and IX were conducted to demonstrate the use of a laser beam to generate an image on an intrinsically hydrophilic sheet having a hydrophobic layer thereon; it is believed the imaged sheet of these examples could, if installed on a suitable press, be used as a printing plate. Other suitable sources of electromagnetic energy may also be used, so long as the energy directed onto the hydrophobic layer is sufficient to cause removal of portions of the layer in the desired image-related configuration. A stencil, mask or the like may be interposed between the energy source and the plate, as discussed herein in connection with other imaging means, if desired. Such a mask or stencil would be advantageous if, for example, the laser or other beam could not be suitably modulated to allow proper formation of a satisfactory image.

It is also foreseen that other means for removing the hydrophobic layer may be used. For example, one or more jets of heated air or other fluid, controlled, for example, by electrically actuated valves, may be positioned to direct

a stream or streams of heated fluid onto the layer, thereby selectively removing at least portions of the layer in the desired image-related configuration, for example, by vaporization or evaporation, and at least partially exposing  
5 the hydrophilic material lying thereunder. In certain applications, a group of well defined, focused streams may be arranged into one or more arrays positioned and/or actuated to impinge upon the hydrophobic layer in the correct sequence to generate the desired latent image. One  
10 or more individual streams may also be employed, with a means for actuating or modulating and traversing or otherwise positioning the streams relative to the hydrophobic layer to form the desired latent image. In other applications, it may be advantageous to employ one or  
15 more relatively unfocused fluid streams which are directed through a stencil, mask, or the like which is interposed between the jets and the plate or the hydrophobic layer thereon. The stencil or mask would be used to assist in directing the fluid streams to the appropriate areas on the  
20 hydrophobic layer and to prevent significant unintended removal of the hydrophobic layer material.

Prior to the application of an oleo ink, and following the selective removal of portions of the hydrophobic layer from the roll in image-complementary configuration, an  
25 aqueous developing material, for example, a conventional aqueous fountain solution, is applied to the roll surface,

by roller stack 40 or other suitable means. It is generally recommended that the fountain solution contain gum or the like in amounts commonly found in commercial preparations.

If, however, a shortened plate image life is desired, as,

5 for example, where the plate is frequently re-imaged with a different image, distilled water or other aqueous liquid may be used as a fountain solution. In either case, the fountain solution adheres to the areas from which the hydrophobic layer material has been removed, forming an

10 image on the roll surface which is the complement of the desired oleo ink image.

To enhance the durability of the hydrophilic areas of the image plate, a gum-containing formulation optionally may be applied to the plate after the imaging step and prior to

15 the application of fountain solution. As discussed earlier, the gum is attracted to the exposed hydrophilic areas and tends to form a protective coating over these hydrophilic areas which is itself hydrophilic. This effectively extends the life of the image on the plate. The gum formulation may

20 be applied by any convenient means in any conventional manner. Customarily, the application of such gum formulation is accompanied by a water wash step in which excess gum is removed. In many cases, a fountain solution containing gum, if allowed to remain momentarily on the

25 imaged plate, is sufficient for use in this gumming step.

Following the application of fountain solution, a layer of an oleo marking material such as an oleo ink is then applied in a conventional manner to the roll surface by roller stack 50 or other suitable means; as is expected in lithographic-type printing systems, the oleo ink adheres only to those areas of the roll surface which are not covered by the aqueous fountain solution. As shown in Figure 1, the roll surface may then be pressed directly against the moving surface of substrate 8 via impression roll 6; alternatively, roll 6 may be an offset or blanket roll 6 by which means the inked image is transferred to the moving surface of substrate 8A, as in conventional offset printing technology. Other intermediate transfer devices such as belts, etc. may also be employed. Substrate 8 or 8A may be comprised of paper, a textile material, or any other suitable material. Any suitable means for moving substrate 8 or 8A may be employed. If desired, the inked image may also be fixed on the roll surface, without subsequent transfer to a substrate.

In those cases where a plate roll is used, and preferably where the roll surface is not merely supporting a separate printing plate, but is in fact acting as the printing plate itself, or where another endless surface such as a belt is used to provide the plate surface, an image may be formed in a continuous manner around the entire perimeter of the roll or belt, with no gap or seam in the plate.

surface to produce a corresponding gap or seam in the printed substrate. The printed image length need not be confined to the length of the plate surface or to an integral divisor of the plate roll or belt circumference, as

5 is necessary in conventional rotary systems. The image length may in fact exceed the plate roll circumference, or the plate roll circumference may be some non-integral multiple of the image length, due to the fact that portions of the image can be continuously erased and reformed on the

10 roll or belt at the same time a previously formed portion of the image on another side of the roll or belt is being printed. Of course, rather than having the actual roll surface serve as the printing plate, a separate thin, perhaps disposable, sheet of intrinsically hydrophilic

15 material as discussed above may be secured to the perimeter of the roll; this thin sheet of material, superficially resembling a conventional lithographic plate, would then serve as the ink image transfer surface rather than the roll surface as described hereinabove. This separate sheet could

20 take the form of a continuous hollow cylinder or sleeve 11 which is secured to the plate roll 10, as depicted in Figure 5, or could alternatively resemble a conventional lithographic printing plate. Also depicted in Figure 5 is a mask 36 which may be employed in an imaging process.

25 Obviously, imaging around the entire circumference of such plate would not be possible unless such plate in fact extended completely around the plate roll.

A principal application of the teachings herein is in the generation of a plate which is imaged one time, and then run without further re-imaging for a relatively large number of plate impressions. Metals which are preferred in this 5 application include nickel, copper, tin, brass, zinc, titanium, zirconium, aluminum, stainless steel, palladium, platinum, lead, and gold. The use of gum preferably in a separate gumming step to protect the hydrophilic areas of the plate is recommended in this application.

10 A second application of the teachings herein is the printing of images wherein the plate is sharpened or refreshed, i.e. the hydrophilic nature of the hydrophilic areas of the printing plate is rejuvenated. This may require nothing more than energizing the imaging means 15 (e.g., electrical styli or other ablation means) at the appropriate time in the printing cycle and in registry with the original image, after most of the ink and fountain solution have been removed from the plate, and thereby removing any scumming (i.e., ink or other undesirable 20 material) present in the hydrophilic or non-ink areas of the plate.

It is also possible, however, and recommended in many situations, particularly if excessive scumming is noted, to clean the roll or plate down to its intrinsically 25 hydrophilic surface, recoat the surface with an adsorbed layer of hydrophobic layer material, and image the roll or

plate with either the same or a different (i.e., a reconfigured) image after a pre-determined number of revolutions of the roll. This can be regarded as a third application of the teachings herein - the periodic complete  
5 re-imaging of the plate, with either the same or a totally different, reconfigured image, during each revolution or after a selected number of revolutions, of the plate roll.

Where complete re-imaging of the roll or plate with a reconfigured image is desired, one may wish to remove the  
- 10 residual ink and hydrophobic layer material previously applied before applying a fresh layer of the hydrophobic layer material. A conventional roll cleaning means may be used to remove the ink and fountain solution which has not transferred to the substrate; alternatively, the press may  
15 be run without ink re-supply until most or all of the ink on the plate has been depleted, and then run without fountain solution re-supply. An additional cleaning means may be helpful in removing the hydrophobic layer material carried by or adsorbed on the roll or plate, as well as any gum  
20 formulation which may have been applied to enhance the durability of the image. This additional cleaning means may simply take the form of an additional imaging means, e.g., a stylus array to which a lithographically "blank" pattern (i.e., resulting in a totally hydrophilic roll surface) may  
25 be directed, thereby requiring all styli to become energized.

It is suggested that, in many applications, a single imaging means may be used for both imaging and cleaning. Referring to Figure 1, the roll cleaning process would involve two sequential revolutions of roll 10, with roll 6 appropriately disengaged. During the first revolution, ink is cleaned off the surface of roll 10 by means of roll cleaning and drying elements 12, 14, and 16, but the hydrophobic layer applicator 20 and roll stack 22 are disengaged, so that no hydrophobic layer material is applied prior to the passage of the roll surface past the imaging means 30 during this revolution. The imaging means 30 is energized with a totally blank pattern, thereby effectively cleaning the roll surface, i.e., substantially removing all significant surface contamination, including hydrophobic layer material and gum which may remain on roll 10 from a prior imaging step. For best results, it may be necessary to use energy levels somewhat higher than would be used or preferred for normal imaging purposes, or to reduce the speed of the roll surface during this cleaning step.

After passing the imaging station, the surface of roll 10 is now free of ink, fountain solution, hydrophobic layer material, gum formulations, and any contaminants or foreign matter, and is dry and entirely hydrophilic. The fountain solution and inking applicators 40 and 50 are also disengaged. The hydrophobic layer applicator 20 and doctoring means 22 are then engaged, resulting in the

application of a continuous, uniform layer of hydrophobic layer material to the clean, hydrophilic roll surface. The imaging, optional gumming, dampening, and inking steps are then performed with roll 6 now pressing against plate roll

5 10.

If sharpening of an existing image without the application of additional quantities of hydrophobic layer material is desired, the imaging means 30 alone may be used to remove, in registry, assorted material from the

10 hydrophilic areas of the plate, and thereby reduce scumming.

For best results, most of the ink and fountain solution on the plate should be removed or allowed to become depleted before the plate is re-imaged by imaging means 30.

Additional energy may be required if excessive material such  
15 as gum, etc., must be removed.

In the embodiment shown in Figure 2, it is assumed that, unlike the embodiment of Figure 1, the image on the roll surface is not replaced or sharpened at selected revolutions of roll 10. Instead, the roll surface is imaged, and

20 multiple copies of that image are printed with no re-imaging. The initial revolutions of roll 10 may be used to clean and image the surface of roll 10, as discussed above. During this time, fountain solution and inking applicators 40 and 50, and roll 6, may be temporarily  
25 disengaged. If the hydrophilic roll material tends to become contaminated with hydrophobic contaminants upon

exposure to the atmosphere, the imaged roll may be gummed, i.e., coated with a formulation containing gum or the like, to establish a hydrophilic coating over the hydrophilic areas of roll 10. Optionally, this coating may be dried before inking and printing. If done promptly following the imaging of roll 10, for example, and before any printing is attempted, this coating will prevent the exposed portions of the roll surface from becoming contaminated or undergoing undesirable chemical reactions with the atmosphere, and will have the effect of preserving the hydrophilic nature of those portions of the surface of roll 10 from which the hydrophobic layer material has been removed, thus contributing to a more durable image on the plate. In the embodiment shown in Figure 2, this coating step may be accomplished by relying upon the gum arabic or the like in the fountain solution, i.e., by engaging fountain solution stack 40 immediately following the imaging of the surface of roll 10, with ink stack 50 and the roll cleaning devices 12 and 14 disengaged, and, optionally, with solvent drying jets 16 in operation. This would require a full revolution of roll 10 during which fountain solution containing gum would be applied to the freshly imaged roll surface and optionally dried, nothing more. Alternatively, a separate gum-containing formulation may be used, applied by means of an appropriate applicator not shown in Figure 2, e.g., a roll stack and doctoring roll, positioned immediately after

stylus array 30 and ahead of fountain solution applicator

40. To further render the plate more wear resistant,  
oleo-type laquer may also be applied in the presence of  
water, which allows the laquer to adhere only to the

5 hydrophobic areas.

After the desired image is placed initially on the  
surface of roll 10 and any steps thought necessary are taken  
to avoid potential oxidation or contamination of the exposed  
hydrophilic surfaces, or to extend the life of the image,  
10 the apparatus used (a) to clean the plate (i.e., solvent  
roll stack 12, doctor blade 14, and solvent drying jets 16),  
(b) to apply the hydrophobic layer material (i.e.,  
applicator 20 and roller stack 22), and (c) to image the  
resulting hydrophobic layer (i.e., stylus array 30, gas  
15 conduit 26, and corona discharge device 28), are all  
temporarily rendered inoperative. With these elements  
(a)-(c) temporarily disengaged, the resulting system  
superficially resembles a conventional printing system, in  
which a fountain solution is applied (via roll stack 40) to  
20 a surface bearing an image defined by hydrophilic and  
hydrophobic areas, which in turn causes the oleo ink applied  
subsequently by roll stack 50 to adhere to the roll surface  
only where the hydrophobic areas repelled the fountain  
solution. This inked image is then transferred to a  
25 substrate as before, using roll 6 as an impression cylinder,  
or as an offset roll. The inked roll is then replenished

with fountain solution and ink, via roll stacks 40 and 50, respectively, and the process repeated. Like the embodiment of Figure 1, and unlike conventional printing systems, however, the hydrophilic areas are formed by the partially exposed roll or plate surface, optionally coated with gum, and the hydrophobic areas are formed by a single thin layer of hydrophobic layer material which is selectively removed from the roll surface without the use of light-sensitive coatings, without any discernible polymerization, cross-linking, or other chemical change to the material in the hydrophobic areas, and without the need for any wash or developing steps.

As suggested above, after imaging, the plate may be used in a conventional manner, with conventional fountain solutions, inks, etc. It is therefore contemplated that a thin sheet of hydrophilic material as described above and cut to appropriate dimensions may be coated and imaged as disclosed herein, and placed in a conventional printing press to generate the multiple printed copies desired. See Examples I - VI. The device depicted in Figure 3, similar to the device of Figure 1 but less the equipment necessary for actual printing of the image (e.g., roll stacks 40 and 50, etc.), may be used for the plate generation and imaging steps independent and apart from the actual printing process, which process may be done on separate, conventional equipment, long after the imaged plate is made.

Having thus outlined several embodiments of printing apparatus and processes, and described various sequences of operation, reference is now made to Figure 7 showing a further embodiment. Unless otherwise noted, elements 5 similar to those previously described have been given the same reference numerals and serve the same functions. In the embodiment shown, the plate comprises an endless surface in the form of a roll 10, which rotates in the direction of arrow 86. Other forms of endless surfaces could be 10 employed, for example, belt-type ink transfer surfaces arranged about a plurality of rolls. Various subsystems, previously described, are arranged about the ink transfer surface along its direction of movement. These subsystems comprise: the cleaning subsystem 62, made up of elements 15 12, 14 and 16; the hydrophobic layer application subsystem 64, made up of elements 20 and 22; the latent image generating subsystem, which may be generalized here as newly numbered element 70; the aqueous fountain solution application subsystem comprising element 40; the inking 20 subsystem comprising element 50; and the image transfer subsystem comprising element 6, and, if desired, element 4.

In the discussion of previous embodiments, the substrate to which the ink image is transferred comprises a web. However, in accordance with conventional practice, the 25 substrate can comprise either a web or individual sheets as desired. In the embodiment of Figure 7, individual sheets

are fed seriatum to the transfer station 6 by a sheet feeder 72 of any desired conventional design, as, for example, feed rolls 74 and bin 76. The feed roll 74 removes the sheet from the bottom of the stack and feeds it to the transfer roll 6 wherein the ink image is transferred to the substrate surface 8. The substrate is then fed to the output bin 78 wherein it is stacked until removal by a machine operator.

5      In the alternative, if roll 6 is used as an offset roll, the ink image is transferred onto roll 6 rather than onto a sheet between roll 6 and roll 10. The ink image is then re-transferred from the roll onto sheet 8A which is fed by a sheet feeder (shown in dotted lines) similar to the sheet feeder 72. Elements 72, 74, 76, and 78 may be regarded as comprising optional elements of the image transfer subsystem. The latent image generating subsystem 70 can be any suitable means, as discussed hereinabove, i.e., a electrical spark discharge system, one or more beams of electromagnetic energy, one or more heated fluid streams, etc., and includes a source of image-forming signals, such as a digital computer.

10     15     20

In a preferred approach, the latent image generating subsystem 70 may be utilized in both forming the latent image and in re-imaging the roll surface. Alternatively, however, a separate re-imaging subsystem 88 may be employed.

25      The separate subsystem 88 can comprise a spark discharge means or any other means as previously discussed in

reference to the latent image generating station 70, and may be arranged, for example, between the cleaning subsystem 62 and the hydrophobic layer application subsystem 64. A primary function of re-imaging subsystem 88 is to clean the 5 surface of roll 10 by removing hydrophobic layer material, gum, etc., which may be present. This is achieved by "imaging" the entire plate, resulting in a lithographically blank, i.e., totally hydrophilic, plate.

Each of the subsystems is selectively operable and their 10 respective operation is controlled by a control system 80. The cleaning roll stack 12 and the doctor blade 14 are actuated by moving them toward and away from the ink transfer surface by means of mechanical actuators such as solenoids or motors with screw drives 82. Similar actuators 15 82 are also employed for moving toward and away from the ink transfer surface the hydrophobic layer application subsystem 64, the latent image generating subsystem 70, the fountain solution application subsystem 40 and the inking subsystem 50. Actuation of transfer roll 6 can be controlled by 20 controlling the sheet feeder 72 or, alternatively, the transfer roll 6 can be moved out of engagement with the ink transfer surface by conventional means. The drying jets 16 are controlled by means of electrically operated valves 84. Accordingly, it is possible for the control system 80 to 25 selectively operate any of the various subsystems by energizing the appropriate actuating systems 82, 84 or 72.

Each time the ink transfer surface comes within operable proximity to the complete sequence of subsystems, e.g., each time roll 10 makes a complete revolution, may be termed a cycle of operation.

5       The control system 80 may be implemented in any conventional manner. For example, it is possible to utilize conventional cam and switch arrangements for selectively actuating the respective actuating systems 82, 84 and 72 to provide any desired sequence of operation. Preferably,  
10      however, in accordance with more current practice, a digital-type control system would be employed utilizing a programmable computer. The advantage of a digital-type system is that a greater variety of operational sequences can be selected. It is foreseen that the same computer  
15      system may serve as both the control system and the source of the electronically generated imagery to be printed.

Such a computer-type controller and associated actuating systems could readily carry out, on a single printing apparatus, all of the various sequencing arrangements needed  
20      to fully carry out the teachings herein. For example, assume the system is required to place a latent image on the previously described plate and print multiple, oleo ink copies, using that same image. This mode of operation may be termed "image and run." During a first revolution of  
25      roll 10, cleaning subsystem 62 alone may be actuated to remove ink or other material from the surface of roll 10.

During the second revolution of roll 10, latent imaging generating subsystem 70 or separate re-imaging subsystem 88 may be employed to clean the roll surface of hydrophobic layer material, gum, etc. which may remain. Such actuation of subsystems 62 and 88 are optional, and may be eliminated if the plate surface is sufficiently clean. Following the optional passage of the roll surface past separate re-imaging subsystem 88, hydrophobic layer application subsystem 64 is actuated, along with latent image generating subsystem 70 and fountain solution application subsystem 64.

Ink subsystem 50 and the image transfer subsystem are not actuated, to allow at least one revolution of roll 10 carrying nothing more than a gum-containing formulation residing on an imaged plate. Applying fountain solution in this manner can serve as an optional gumming step to enhance the longevity of the hydrophilic portions of the plate, as discussed earlier. Drying jets 16 may be optionally employed at this point in the process. Of course, if a separate gum-containing formulation is to be used, a separate gum application and water jet wash subsystem 63, schematically depicted at 18 and 19, respectively, in Figure 8, may be desired. Control system 80 could be modified appropriately to accommodate the addition of such subsystem.

After the image on the plate has been generated and, optionally, gummed, only the fountain solution application subsystem 40, inking subsystem 50, and the image transfer

subsystems are actuated, which results in the printing of the same image with each revolution of roll 10.

If a change in the image is desired at this point, several options are available. If a complete re-imaging of 5 the plate is desired and the plate has been gummed, a preferred approach is to begin as above, with the actuation of only cleaning subsystem 62, followed by activation of latent image generating subsystem 70 or separate re-imaging subsystem 88, etc., in order to clean thoroughly the roll 10 surface. If no gum was used, the actuation of these latter subsystems may be unnecessary, and in many cases a fresh layer of hydrophobic layer material may be applied over the existing hydrophobic layer, providing little or no ink 15 remains on the plate. The adsorbed character of the layer, which contributes a self-leveling quality to the material in layer form, along with the method of application, can result in a suitable thickness of material being applied. Following this re-application of hydrophobic layer material, the plate is then imaged, dampened, inked, and the image 20 transferred to the substrate, as before.

It should be noted that the above-described sequences of actuation are but a few of the possible sequences which may be found to be advantageous under various circumstances. Other sequences may be employed, as desired, to achieve 25 improved printing operation.

The previously described process results in a printing plate in which those areas of the hydrophilic plate surface intended to carry an oleo ink are coated with a hydrophobic layer material, while the non-image areas of the hydrophilic plate surface are thought to be at least partially exposed.

Where desired, a layer of gum may be made to cover these partially exposed areas, thereby rendering these areas more durably and decisively hydrophilic. The method for generating such a plate described previously may be summarized as follows: (1) coat the hydrophilic plate surface with a thin layer of hydrophobic layer material, (2) selectively remove the layer in the desired configuration, and, (3) as an optional step, coat the resulting plate with gum, the gum ordinarily adhering only to the exposed portions of plate surface. Alternative processes for generating the above described plate, as well as alternative printing plate constructions, however, are possible.

The above plate comprising hydrophobic layer material and gum in contiguous areas may be generated either by selective removal of a uniform layer of hydrophobic layer material, followed by a gumming step, as summarized above, or, for example, by (1) covering the plate surface with a thin layer of gum, (2) removing selectively portions of the gum layer in a desired configuration and (3) coating the resulting plate with a hydrophobic layer material. Many hydrophobic layer materials will not readily cover the

remaining portions of the gum layer, but will instead preferentially coat the now-exposed portions of the plate surface. The result is a plate comprising hydrophobic layer material and gum in contiguous areas, as before. Note,

- 5 however, that (1) the removal step was performed on the gum rather than the hydrophobic layer material, and (2) the removal step involved tracing the complement of the configuration used before.

An alternative method for generating plates similar in  
10 general construction to those disclosed above, which also results in the placement of hydrophobic layer material on the plate in an image-related, pre-determined configuration comprises selectively applying the hydrophobic layer material in the appropriate configuration, rather than  
15 selectively removing the material from a uniform layer, as has been described above. This method may be implemented using, for example, an ink jet printing assembly or other means which is supplied with a source of hydrophobic layer material of appropriate viscosity rather than ink. Many of  
20 the materials listed in Table I are suitable for this application. The ink jet printing assembly may be substituted for the hydrophobic layer application subsystem 64 and the layer-removal portion of the latent image generating subsystem 70 in the apparatus of Figure 7. In  
25 other words, in Figure 7, the hydrophobic layer application subsystem 64 may be disengaged, and the latent image

generating subsystem 70 may comprise an ink jet assembly, or an array of such assemblies, which applies the chosen hydrophobic layer material in the proper configuration. The use of a stencil, mask, or similar device may be used to aid 5 in properly configuring the hydrophobic layer material, as before.

As suggested above, alternative plate constructions are also possible. Where a durably-imaged plate is desired, for example, a suitable plate may be generated by (1) covering 10 the hydrophilic plate surface with a thin underlayer of gum, (2) coating the gum underlayer with a thin overlayer of hydrophobic layer material, and (3) selectively removing the overlayer of hydrophobic layer material in the desired configuration, without substantially disturbing the 15 underlying gum. Depending upon the choice of materials, it has been found that application of the hydrophobic layer material while in the vapor state, and allowing the material to condense onto the gum surface, or heating the hydrophobic layer material prior to application, aids in the formation 20 of the requisite hydrophobic overlayer recited in step (2).

The chemical properties of most gums, particularly their significantly higher molecular weight, allow them to adhere well to exposed portions of the plate surface. In most cases, the gum layer is relatively more difficult to remove 25 and tends to remain intact compared with the hydrophobic layer material, and the imaging energy may be readily

adjusted to accomplish this layer-selective removal with many combinations of gum formulations or similar materials and hydrophobic layer materials. The result is a plate wherein the hydrophilic areas are comprised of the 5 hydrophilic plate surface, coated by a layer of gum, and the hydrophobic areas are comprised of the hydrophilic plate surface coated with a layer of gum, which layer in turn is coated with an overlayer of hydrophobic layer material. As suggested above, this same plate construction may be 10 achieved by selective addition of the hydrophobic layer material over the gum in the desired configuration, via an ink jet or other means, rather than selective removal of the material from a uniform overlayer. The use of an ink jet or other selective applicator could also be employed to 15 generate a plate wherein the plate surface is first uniformly coated with a hydrophobic layer material, followed by the selective application of a hydrophilic layer of gum, e.g., by ink jet, in an image-related configuration.

The printing processes described hereinabove have 20 generally assumed use of a substantially planographic printing plate wherein the image areas of the plate comprise regions which are relatively hydrophobic and wherein the non-image or image-complementary areas of the plate comprise regions which are relatively hydrophilic. In conventional 25 lithographic printing processes, an oleo ink is applied to a plate surface which has been selectively wetted, in

image-complementary configuration, with an aqueous fountain or dampening solution. The plates used in these processes, however, are also suitable for use in printing systems employing aqueous inks. In their simplest form, such

5 systems may be thought of as lithographic systems in which an aqueous-type ink is made a component of the aqueous fountain solution. Such composite solution may be applied in the same manner and sequence as a conventional fountain solution, e.g., through the use of roll stack 40 or other suitable applicator. No ink is applied via applicator 50,

10 which may be disengaged. The ink carried in the fountain solution is transferred to a substrate as before, i.e., either directly or via an offset roll or the like. Because the ink now resides in the hydrophilic areas, rather than in

15 the hydrophobic, oleophilic areas as before, the image "sense" of the plate must be transposed, i.e., the hydrophobic layer material must now be configured in an image-complementary configuration and the hydrophilic areas of the plate must be in image configuration, rather than

20 vice versa, as before. This means that the electronic image generating means which controls the selective application or removal of the hydrophobic layer material must be modified to impart the desired signals to the imaging means. (As discussed earlier, a more general term, "image-related

25 configuration", may be used to describe the configuration of either the hydrophilic or hydrophobic areas. Alternatively,

the latent image may be said to correlate with the resulting ink image, in that one either directly implies or is complementary to the other.) The process of cleaning aqueous ink from the roll may be somewhat different than in 5 the oleo ink case, the hydrophobic layer material should now no longer have an affinity for the printing ink used, and other obvious differences may be found, but the overall printing process, as distinguished from the imaging process, is otherwise substantially similar, and may be used in 10 situations where aqueous inks are advantageous.

Consideration of the alternative processes and plate constructions, and use of aqueous rather than oleo inks, as discussed above, does not change significantly either the manner in which the various plates may be generated, imaged, 15 erased, re-imaged, or used in a printing process, or the apparatus which would be used to effect such operations, in accordance with the processes and apparatus previously described, except in ways which would be readily apparent to those skilled in the art. Assume, for example, a 20 durably-imaged plate comprising a complete, specially gummed underlayer and a configured overlayer of hydrophobic layer material is to be generated and run without re-imaging in an apparatus along the lines of that depicted in Figure 7. The apparatus depicted in Figure 8 is similar to that depicted 25 in Figure 7, except that a hydrophilic layer applicator subsystem 63, comprising gum applicator 18 and wash means

19, and appropriate actuators 82, have been added immediately prior to the hydrophobic layer applicator subsystem. The sequence for the previously described "image and run" mode of operation may be followed, except that,

5      immediately prior to the actuation of hydrophobic layer application subsystem 64, hydrophilic layer applicator subsystem 63 is actuated, causing a uniform, thin layer of the gum formulation to be deposited on the hydrophilic surface of roll 10. Optionally, roll 10 may be allowed to

10     revolve one or more times to allow the gum formulation to dry. Following this gum application step, all remaining steps of the "image and run" mode of operation are followed. If aqueous ink, added to the fountain solution, is to be used rather than oleo ink, the principal necessary changes

15     to the above would be (1) disengagement of ink subsystem 50, and (2) adjustment of latent imaging generating subsystem to remove the hydrophobic layer material in image, rather than image-complementary, configuration.

Re-imaging of the plate discussed above is relatively

20     easy, particularly if an aqueous ink is used, due to the uniform, somewhat tenacious layer of gum residing on the plate surface and the ease with which the aqueous ink may be removed via cleaning subsystem 62. Layer-selective removal of the entire layer of hydrophobic layer material is readily

25     accomplished, for example, by activation of re-imaging subsystem 88. Re-application of a gum layer, if

necessary, may be accomplished via optional actuation of hydrophilic layer application subsystem 63. The natural self-leveling tendency of gum prevents excessive gum build-up. All the re-imaging steps above, as well as the 5 application of a fresh layer of hydrophobic layer material, followed by re-imaging and printing, could be achieved within a single revolution of roll 10 if desired.

A non-planographic, gravure-type cylinder having a contoured surface which is intrinsically hydrophilic, as 10 discussed herein, may be substituted for the planographic plate roll discussed above, with the benefit of advantages analogous to those discussed above. The physical configuration of the surface may be among those ordinarily chosen by those skilled in the art; the shape at the 15 depressions, cells, grooves, etc., which comprise the contoured surface is not important. The term cell is intended to include all such features. Beginning with a substantially clean cylinder, the desired hydrophobic layer material may be applied either by applying a thin, uniform 20 layer to the cylinder surface and selectively removing, e.g., by ablation, material from the surface of those cells intended to accept an aqueous developing liquid, e.g., an ink, or by selectively applying, e.g., by ink jet methods, a coating or layer of material to the interior surface of the 25 desired cells. It should be noted that, preferably, the material and application means are chosen to permit the

application of a monomolecular or near-monomolecular layer of the material which coats the walls and floor, or portions thereof, of the desired cells and conforms thereto. It is not necessary that the hydrophobic layer material fill, to 5 any significant extent, the cell interiors. Treating the cylinder surface with a gum-containing formulation either prior to application of the hydrophobic layer material or after imaging, to enhance the durability of the cylinder image, is optional. Figure 11 depicts a magnified 10 perspective view of a cross section of the surface of a conventionally configured gravure roll 104 which has been imaged by arrangement of a hydrophobic layer material over its hydrophilic surface. Shaded roll cells 106 carry an adsorbed, thin hydrophobic layer; unshaded cells 108 carry 15 no hydrophobic layer material, and are therefore comprised of the exposed intrinsically hydrophilic material from which the roll is made, or a hydrophilic protective layer such as a gum layer. Boundary 109 indicates that only a portion of an individual cell need carry the hydrophobic layer 20 material.

Once the roll has been thus imaged, printing may be done in accordance with conventional gravure printing practice. Application of an aqueous ink to the cylinder surface, followed by a doctoring step, produces an ink image on the 25 cylinder comprised of the cells which do not contain the hydrophobic layer material. The image is then transferred

to a suitable substrate by conventional means, e.g., direct cylinder-to-substrate contact. As discussed above, if an oleo ink is used along with a separate fountain solution and fountain solution applicator, the "sense" of the image on 5 the cylinder must be changed so that those cells intended to carry ink also carry a quantity of hydrophobic layer material.

The resulting gravure cylinder may be easily re-used, i.e., re-imaged, by cleaning ink from the cells and surface 10 of the cylinder using conventional methods, and removing, e.g. by ablation, all remaining hydrophobic layer material or other material from the cells. After thus thoroughly cleaning the cylinder of all dirt, coatings, etc., a fresh quantity of hydrophobic layer material may be applied as 15 before, i.e., either selectively in the desired configuration, or as a uniform layer for subsequent selective removal. It should be noted that, with the invention herein described, the possibility exists to generate half tones by varying the individual intra-cellular 20 area coated by the hydrophobic layer material, i.e., the amount of interior cell surface which is coated with a layer of hydrophobic layer material within individual cells may vary.

The various sequences of cleaning, imaging, printing, 25 re-imaging, etc., and the automated manner in which these processes may be carried out, as discussed above in

connection with planographic plates, are equally applicable where a gravure roll is used, except for modifications which will be apparent to those skilled in the art and which are dictated by conventional gravure printing procedures.

- 5        A seamless cylindrical screen similar to that used in conventional screen printing methods also may be substituted for the planographic plate roll discussed herein, with all of the advantages analogous to those discussed above which are appropriate for such a screen system. A reusable screen
- 10      may be fashioned by installing a clean, open, relatively fine mesh (for example, about 100 x 100 mesh or finer, depending upon the desired viscosity of the ink, etc.) unimaged screen having mesh elements comprised of an intrinsically hydrophilic material, as discussed herein, on
- 15      an apparatus similar to that depicted in Figure 9. Rather than a solid plate roll, a cylindrical, substantially hollow revolving frame 90 is used, driven by any convenient means around which screen 92 is stretched. A suitable hydrophobic layer material as disclosed herein may be applied to the
- 20      mesh elements comprising the mesh surface of screen 92 by means of roll stack 20 or other suitable means. Doctoring means 22, comprised of a water jet wash system 24 and a doctoring or kiss roll 23, are intended to remove excess hydrophobic layer material from screen 92. Other doctoring
- 25      or metering devices, such as a soft doctor blade, could be used as well. Rolls 97, 99 serve to prevent deformation of

screen 92, and may supply energy to rotate frame 90 and screen 92 in the direction indicated. The uniform quantity of hydrophobic layer material adhering to the surface of screen 92 after passing doctoring means 22 may be

5 selectively removed by any convenient means, e.g., a laser system 30, as discussed above and depicted in Figure 9.

Figure 12 depicts a magnified perspective view of a cross-section of a printing screen 110 which carries a quantity of hydrophobic layer material in the upper left, 10 shaded portion. The material is adsorbed on the wire mesh in area 112, and does not occlude the screen openings 114; wire mesh outside area 110, as depicted at 116, remains substantially hydrophilic. Following the selective removal of hydrophobic layer material from the surface of screen 92, 15 ink is then applied thereto, as by roll train 50 or other suitable means. A high surface tension, low viscosity aqueous ink is generally preferred. The ink is held within the screen interstices only in those regions of the screen wherein the hydrophobic layer material has been removed, and nowhere else. It should be emphasized that it is not necessary that the hydrophobic layer material cover or fill the selected interstices from which an aqueous ink or other aqueous developer material is to be excluded. The layer material may therefore be considered substantially non-occlusive. The aqueous ink is then transferred to a

25 substrate, as explained above. It is foreseen, however,

that if a process resembling a conventional lithographic process is desired, using a screen in place of a solid lithographic plate, an oleo, lithographic-type ink may be used, along with a suitable fountain solution or other 5 aqueous developer material. In this case, the oleo ink is held within the screen interstices only in those regions of the screen where the hydrophobic layer material remains.

Other techniques for removing the hydrophobic layer material, as discussed above, may be used. Because it is 10 only necessary to arrange the desired quantity of hydrophobic layer material on the screen in an image-related, configuration, the hydrophobic layer material may be selectively applied to the screen surface, as, for example, by using a ink jet-type system, as discussed above, 15 rather than uniformly applied and selectively removed. Use of a gum-type treatment, either before application of the hydrophobic layer material, or after imaging, is optional.

When a new image is desired, the screen may be cleaned of ink, by any suitable method, and of all hydrophobic layer 20 material by, for example, use of an ablation means as discussed above. After the screen has thus been thoroughly cleaned and is once again completely open, the screen may be imaged again, by appropriate arrangement of hydrophobic layer material, as above, in the desired new configuration. 25 If, for example, non-continuous imaging or non-seamless printing is desired, a non-cylindrical screen can be

employed as well, with appropriate modification to the imaging and printing methods and apparatus. The various sequences of cleaning, imaging, printing, re-imaging, etc., and the automated manner in which these processes may be  
5 carried out, as discussed above in connection with planographic plates and gravure rolls, are equally applicable where a print screen as described herein is used, except for modifications which will be apparent to those skilled in the art and which are dictated by conventional  
10 screen printing procedures.

The following examples are merely intended to demonstrate some of the preferred embodiments of the present invention, and in no way are intended to limit the scope of the invention.

## EXAMPLE I

A five mil (0.005 inch) thick plain stainless steel sheet supplied by the Precision Steel Warehouse, Inc. of Downers Grove, Illinois, was placed in a 600°F oven for five minutes to vaporize any surface contaminants which may have been present on the sheet surface. The sheet was then mounted on a grounded steel plate cylinder. A small amount of a solution comprising 0.2 grams of hexadecanoic acid dissolved in 100 ml distilled water and 100 ml isopropyl alcohol was then wiped by hand onto a four inch by four inch area in the central region of the sheet, thereby rendering that area hydrophobic. The region of the sheet outside the four inch by four inch area remained clean of contaminants, and was therefore substantially hydrophilic.

A linear stylus array comprising tungsten wires approximately 10 mils in diameter supplied by the California Fine Wire Company, of Grover City, California, with an adjacent wire spacing of approximately one-half inch, was positioned so that the distance between the wire tips and the stainless steel sheet surface was approximately three mils. The wires were held in an insulating matrix of glass filled epoxy and glass fiber reinforced board. Each wire was connected through a 100,000 ohm resistor and a switch to a +800 volt D.C. power supply. The cylinder carrying the stainless steel sheet was rotated at a circumferential speed of approximately four yards per minute while the switch to

the wires was closed, completing the connection with the power supply. The stainless steel sheet was held at ground potential via contact with the grounded cylinder. Argon gas was directed to the region of the wire tips, at a rate of 5 approximately 3 C.F.H. As the sheet surface passed under the wires, electrical arcs occurred between the wire tips and sheet surface, thereby imaging the surface. After a single pass of the sheet under the wires, the switch was opened and the sheet was removed from the cylinder and 10 stored in distilled water, to prevent oxidation or contamination of the clean hydrophilic areas of the sheet traced by the arcs.

Several hours later the sheet was removed from the water and mounted in a Multilith 1250 Offset Lithographic 15 Duplicator (distributed by A M International, Los Angeles, California) in place of a conventionally prepared lithographic plate. The duplicator was inked with Pantone Process Brown ink, (supplied by A M Multographics, a division of A M International, Mt. Prospect, Illinois). The 20 fountain solution used was a solution of one part (by volume) 3M Duplicator Fountain Concentrate, supplied by 3M Printing Products Division, St. Paul, Minnesota, and 31 parts (by volume) distilled water. After mounting the sheet, the duplicator was run in the normal fashion, with 25 the dampening rolls applying fountain solution to the sheet surface, followed by the inking rolls applying ink to the

sheet surface. The fountain solution was observed to wet only those areas of the four inch by four inch region where the arcs had impinged. The ink, being immiscible with the fountain solution, coated only the remainder of the four  
5 inch by four inch region containing no fountain solution. The rest of the plate, being uncontaminated, wet with the fountain solution and therefore did not accept ink. The inked image was transferred to the blanket cylinder where it was transferred to paper. A clean, sharp, well-defined  
10 image resulted on the paper which was the complement of the area traced by the arcs, i.e., a four inch by four inch inked region carrying uninked lines corresponding to the region traced by the arcs. The sheet was used to print multiple copies on paper. No significant image degradation  
15 was observed.

## EXAMPLE II

The procedures of Example I were followed, except as noted below. A five mil thick plain aluminum sheet, from the same supplier, was used in place of the stainless steel sheet. The sheet was cleaned with alcohol and placed in a 600°F oven for one minute to vaporize any surface contaminants. After the sheet was imaged, it was removed from the cylinder and a diluted solution of fountain solution (Formula 100 fountain solution, distributed by AM Multographics, Mt. Prospect, Illinois) and distilled water in a volume ratio of 1:32 was applied and allowed to air dry. The plate was not stored under water. The next day the plate was mounted on the press, and multiple copies of a clean, sharp, well-defined image were recorded on paper, with no discernible trace of image degradation. Intentional fouling of the hydrophilic areas of the plate with ink resulted in a self-cleaning action by the plate; printing of clean, sharp, well-defined images promptly returned.

## EXAMPLE III

A five mil thick plain stainless steel sheet supplied by the Precision Steel Warehouse, Inc. of Downers Grove, Illinois, was mounted on the plate cylinder of a Multilith 1250 Offset Lithographic Duplicator, made by A M International, of Los Angeles, California, in place of a conventionally prepared lithographic plate. A linear array comprising parallel tungsten wires 10 mils in diameter and spaced 25 wires per linear inch supplied by the California Fine Wire Company, of Grover City, California, was positioned so that the distance between the wire tips and the plate was approximately three mils. The wires were held in an insulating matrix of glass filled epoxy and glass fiber-reinforced resin board. Each wire was connected through a 100,000 ohm resistor to a +700 volt D.C. power supply through a switch. Prior to mounting, the surface of the stainless steel sheet had been immersed in a fifty per cent (by weight) solution of sodium stearate in distilled water (prepared by heating the mixture to a temperature of about 50°C and cooling), and then rinsed with streams of distilled water and briefly air dried, leaving the sheet uniformly hydrophobic. The duplicator was inked with O/S H/T Process Blue fifteen per cent 23401 ink, made by Sinclair and Valentine Co., of Charlotte, North Carolina. The fountain solution used was a solution of 31 parts (by volume) water and one part (by volume) RBP Craftsman.

Fountain Solution Soft Number 290701, supplied by Research for Better Printing Chemical Corporation, Milwaukee, Wisconsin.

With the dampening and inking rollers disengaged from  
5 the sheet, the plate cylinder was rotated at a circumferential speed of approximately four yards per minute while the switch to the wires was closed, completing the circuit to the power supply. The stainless steel sheet was held at ground potential via connection with the grounded  
10 duplicator frame. Argon gas was directed to the region of the wire tips, at a rate of approximately 3 C.F.H. As the sheet surface passed under the wires, electrical arcs occurred between the wire tips and the sheet surface.

After a single pass of the sheet under the wires the  
15 switch was opened, the plate roll speed was increased to twenty yards per minute, and the dampening roll was brought into operative engagement with the sheet. The fountain solution wet only those areas of the sheet where the arcs had impinged. After several revolutions of the plate  
20 cylinder in operative engagement with the dampening roll, the inking rolls of the duplicator were brought into operative engagement with the sheet. The ink, being immiscible with the fountain solution, was repelled by those areas wet by the fountain solution, and coated the surface  
25 of the sheet only in those areas not wet by the fountain solution, i.e., those areas where the arcs had not impinged.

The inked image was then transferred to the blanket cylinder where it was then transferred to paper. A clean, sharp, well-defined image was printed on the paper which was the complement of that image traced by the arcs, i.e., the paper  
5 showed a solid inked area with a series of sharp, inked lines corresponding to the regions traced by the arcs. The sheet was used to make multiple copies of the image; no discernible degradation in image quality was observed. The sheet was then cleaned manually with mineral spirits, and  
10 the sheet was recoated with the sodium stearate solution and rinsed with distilled water, as before. The imaging and printing processes described above were repeated. Again, the result was a series of clean, sharp, well-defined images of uninked lines traced within a region of solid ink,  
15 similar to those obtained earlier. There was no visible trace of the earlier image.

## EXAMPLE IV

The surface of a glass roll approximately 4 inches in diameter and comprised of 60%  $\text{Al}_2\text{O}_3$  and 40%  $\text{TiO}_2$  was first cleaned with isopropyl alcohol and then wiped dry. Then a  
5 solution of 50% hexadecanoic acid and 50% isopropyl alcohol (by volume) was applied with a cotton swab, and the excess was washed off with a stream of distilled water, presumably leaving a thin layer. After air drying, the roll was imaged using a 10 mil diameter tungsten stylus, spaced 2.0 mils  
10 from the roll surface. An electrical current of 8 milliamps at +800 volts was established in a spark discharge between the roll and the stylus, as the roll turned at a circumferential speed of 4.6 ypm, thereby causing the arc to trace a line on the roll surface. Argon gas was fed into  
15 the region of the discharge, at a rate of about 10 C.F.H. and at essentially atmospheric pressure.

A mixture (by weight) of 1 part 3M Duplicator Fountain Concentrate, distributed by 3M Printing Products Division, St. Paul, Minnesota, and 15 parts of distilled water, was  
20 applied to the general area of the roll surface carrying the image and allowed to remain momentarily. A roller was used to apply an additional quantity of the above solution, which was observed to wet only the imaged area. A  
25 lithographic-type ink (Offset Black BI8261, manufactured by Burntwood Industried, Inc., of Addison, Illinois) was then applied to the general area of the roll surface carrying the

image via a roller. The ink adhered to the roll surface only where the fountain solution had not wet the roll, i.e., in those areas which had not been imaged by the spark discharge. The ink image was then transferred to paper. A sharp, well-defined printed image was observed. Additional quantities of fountain solution and ink were sequentially applied to the general area of the roll surface carrying the image, and the image again transferred to paper. As before, a sharp, well-defined printed image was observed.

## EXAMPLE V

A 4" x 1" section of five mil (0.005 inch) thick type 304 stainless steel sheet supplied by the Precision Steel Warehouse, Inc. of Downers Grove, Illinois, was rinsed with 5 a stream of isopropyl alcohol, air dried, and placed in a 600°F oven for one minute to vaporize any surface contaminants which may have been present on the sheet surface. The sheet was then dipped in a solution comprising 0.2 grams of hexadecanoic acid dissolved in a solution of 10 100 ml distilled water and 100 ml isopropyl alcohol and rinsed promptly in cold tap water, thereby rendering the sheet hydrophobic. The sheet was then dried in a stream of nitrogen gas and securely mounted on a grounded, steel cylinder in order to image the sheet surface. A single 15 tungsten wire approximately 10 mils in diameter supplied by the California Fine Wire Company, of Grover City, California, was positioned so that the distance between the wire tip and the stainless steel sheet surface was approximately three mils. The wire was held in an 20 insulating sandwich of acrylic plastic. The wire was connected through a 100,000 ohm resistor and a switch to a D.C. power supply adjusted to deliver +800 volt pulses at a frequency of 17 KHz. The cylinder carrying the stainless steel sheet was rotated at a circumferential speed of 25 approximately 1.2" per second while the switch to the wire was closed, completing the connection with the power supply.

The stainless steel sheet was held at ground potential via contact with the grounded cylinder. Argon gas was directed to the region of the wire tips, at a rate of approximately 3 C.F.H. As the sheet surface passed under the wires, an electrical arc occurred between the wire tip and sheet surface. After a single pass of the sheet under the wires, the surface was imaged and the switch was opened. The sheet was removed from the cylinder, rinsed with a 1:15 solution (by volume) of 3M Fountain Solution, distributed by 3M Printing Products Division, St. Paul, Minnesota, and distilled water. The solution was left standing on the sheet for five minutes, thereby gumming the plate. The sheet was then rinsed with distilled water and inserted in a prepared cut-out in the central portion of a 3M R-Type plate, distributed by 3M Printing Products Division, St. Paul, Minnesota, which had been imaged previously with a diagnostic pattern, thereby forming a "hybrid" plate. The "hybrid" plate was then mounted in a Multilith 1250 Offset Lithographic Duplicator (made by AM International, Los Angeles, California) in place of a conventionally prepared lithographic plate. The duplicator was inked with Pantone Process Blue No. 530-8000, (supplied by AM Multigraphics, a division of AM International, Mt. Prospect, Illinois). The fountain solution used was a solution of one part (by volume) Rosos Fountain Solution G-7A-V-Comb, supplied by Rosos, Inc., Lake Bluff, Illinois, and 31 parts (by volume)

distilled water. After mounting the sheet, the duplicator was run in the normal fashion, with the dampening rolls applying fountain solution to the sheet surface, followed by the inking rolls applying ink to the sheet surface. The 5 fountain solution was observed to wet only those areas of the stainless steel insert where the arc had impinged. The ink, being immiscible with the fountain solution, coated only the remainder of the stainless steel insert containing no fountain solution. The rest of the plate, i.e., the 10 conventional, diagnostically imaged plate, was selectively wet with the fountain solution as expected and, accepted ink in the diagnostic image areas. The inked image carried by the entire hybrid plate was transferred to the blanket cylinder, where it was transferred to paper. A clean, 15 sharp, well-defined ink image resulted on the paper, which included an uninked line representing the area traced by the arc on the stainless steel insert. The sheet was used to print multiple copies on paper. No significant image degradation was observed.

20 To determine the erasability of the plate, and its suitability for re-use, the stainless steel insert was removed from the hybrid plate and cleaned by hand using Blankrola , distributed by AM Multographics, of Mt. Prospect, Illinois. After air drying, the insert was rinsed 25 with isopropyl alcohol and again air dried. The shim was securely re-mounted on the grounded steel cylinder at

## EXAMPLE VII

A 4" x 1" section of five mil thick type 304 stainless steel sheet, supplied by the Precision Steel Warehouse, Inc. of Downers Grove, Illinois was placed in an oven at 650°F 5 for one minute, then dipped in the hexadecanoic acid solution of Example IV. The section was mounted on the apparatus of Example IV, with the cylinder traveling at the rate of 4.6 yards per minute, the imaging procedures of Example IV were followed. The gumming solution of Example 10 IV was applied and let dry. An ink/fountain solution mixture comprising 60 ml of the above gumming solution and 10 drops of TERAPRINT Blue R disperse dye, distributed by Ciba Geigy Corporation, Greensboro, North Carolina, was applied to the sheet by a roller. The mixture adhered to 15 the sheet only where the spark had traced, and nowhere else. The inked surface of the sheet was then pressed against a sheet of paper, whereupon the ink transferred to the paper, forming a clear, sharp image of the path traced by the spark. Re-application of the mixture to the sheet, and the 20 subsequent transfer to paper, yielded similar results.

## EXAMPLE VIII

A stainless steel sheet and a copper sheet, each 5 mils thick and each supplied by Precision Steel Warehouse, Inc., of Downers Grove, Illinois, were separately illuminated by a pulsed ruby laser manufactured by Apollo Lasers, Inc. of Los Angeles, California. The laser had an average beam energy of 3.5 Joules, a beam cross-sectional area of approximately 0.0123 square inches, and a pulse width of 40 nanoseconds.

The sheets were untreated before illumination, and therefore carried a film of machining oils and other materials associated with the manufacturing process which rendered the sheet surfaces hydrophobic as observed with distilled water. Immediately after illumination each sheet was dipped in distilled water and quickly withdrawn. The distilled water wet and adhered to each sheet in the precise area illuminated by the laser; all other areas of the sheets remained water repellent, indicating that the hydrophobic layer had been selectively removed in a pre-determined configuration and a precise, well-defined hydrophilic/hydrophobic image had been inscribed onto each sheet.

## EXAMPLE IX

The procedure of Example VIII was repeated, using 5 mil sheets of zinc and aluminum by Alfa Products of Danvers, Massachusetts, in place of the stainless steel and copper sheets. Similar results were obtained.

## EXAMPLE X

A small grooved roll similar to a rotogravure roll and having 120 grooves per linear inch, arranged in approximately a 45° helix was placed in an oven at 600°F for 5 one minute to clean the surface. The roll was then dipped in the hexadecanoic acid solution of Example V and immediately rinsed with water. The roll was then imaged, using the procedures of Example V, except the voltage was +950 volts, the series resistance was 200 kilohms. Four 10 short, evenly laterally spaced dashes were traced by the spark. The roll was then squirted with an ink comprising (by volume) 50% distilled water and 50% Sheaffer Skrip blue fountain pen ink, distributed by Sheaffer Eaton, Fort Madison, Iowa. A rubber doctor blade was used to remove 15 excess ink. The ink wet only those areas of the roll traced by the sparks. The roll was pressed against a sheet of paper. Four short, inked dashes were formed on the paper. Multiple copies were produced. All images were clean and sharp.

## EXAMPLE XI

A small section of stainless steel screen (120 x 108 mesh) supplied by McMaster-Carr, Inc., Elmhurst, Illinois, was first placed in an oven at 600°F for one minute, then 5 briefly dipped in the hexadecanoic acid solution of Example V. The screen was then promptly rinsed with water, and then attached to the apparatus of Example V. The imaging procedures of Example IV were followed. The screen was made wettable in the area traced by the spark. The imaged screen 10 was then dipped in distilled water to which a small quantity of Pelikan Yellow drawing ink distributed by Pelikan AG, Hannover, West Germany, had been added. Only the area traced by the spark held ink. The screen was then pressed against paper, and a clear, sharp image was transferred. 15 Repeated images were printed, with only ink resupply necessary.

While specific components of the present system are disclosed above, many variations may be introduced which may in any way enhance, improve, or otherwise affect the system. 20 While specific variations are given in this description, modifications and ramifications occur to those skilled in the art upon reading this description are also intended to be included herein.

CLAIMS

1. An image-carrying printing element comprising a support provided with a hydrophilic surface, and a hydrophobic layer having an image-related configuration superposed over the support, characterised in that the support (10, 11, 92, 104, 110) is composed of intrinsically hydrophilic material, that the hydrophilic layer (100, 106, 112) is in direct contact with a hydrophilic surface of the support and that the hydrophilic surface is exposed in the complement of the said configuration (102, 108, 116) to an extent sufficient to confer hydrophilic properties on the exposed area.
2. A printing element according to claim 1, characterised in that the support (11, 104) is composed of a hydrophilic metal, preferably stainless steel or aluminum.
3. A printing element according to claim 1 or 2, characterised in that the hydrophobic material (100, 106, 112) is non-polymerisable and non-light-sensitive, and is preferably selected from carboxylic acids, carboxylic acid salts, carboxylic acid anhydrides, and polymers, or from hexadecanoic acid, octadecanoic acid, polyvinyl butyral, and acrylic resin.
4. A printing element according to any of claims 1 to 3, characterised in that the element (10, 11) is a planographic printing plate, roll or cylinder.
5. A printing element according to any of claims 1 to 3, characterised in that the element is a gravure printing plate or cylinder (104).
6. A printing element according to any of claims 1 to 3, characterised in that the element is a printing

screen (92, 110) and the support comprises a mesh composed of an intrinsically hydrophilic material.

7. A method of preparing a printing element, characterised in that a layer of substantially hydrophobic material is arranged in an image-related configuration on the hydrophilic surface of a support, and that the complement of the said configuration is rendered substantially hydrophilic relative to the area of the said configuration.

8. A method according to claim 7, characterised in that a substantially uniform layer of the hydrophobic material is applied to the surface of the support and that the hydrophobic material is then removed from the said complement of the image-related configuration by physical ablation to an extent sufficient to render the complementary areas substantially hydrophilic, while retaining the hydrophobic material within the said configuration in substantially unchanged condition.

9. A method according to claim 8, characterised in that the hydrophobic material is substantially removed by an electric discharge, beam of electromagnetic energy or jet of heated fluid.

10. A method according to claim 7, characterised in that the hydrophobic material is non-polymerisable and non-light-sensitive, and is preferably selected from carboxylic acids, carboxylic acid salts, carboxylic acid anhydrides, and polymers, or from hexadecanoic acid, octadecanoic acid, polyvinyl butyral, and acrylic resin.

11. A method according to any of claims 7 to 10, characterised in that the hydrophobic material is applied directly to a clean surface of an intrinsically hydrophilic support, preferably of stainless steel or

aluminum, without the interposition of any layer of another hydrophilic material.

12. A method according to any of claims 7 to 11, characterised in that the hydrophobic material is arranged in a computer-addressable manner or with the interposition of a mask or stencil determining the image-related configuration.

13. A method according to any of claims 7 to 12, characterised in that, after an ink image has been formed on the prepared printing element and transferred to a substrate surface to be printed, the surface of the element is cleaned to expose the intrinsically hydrophilic material thereof, a second layer of substantially hydrophobic material is arranged as aforesaid, a second ink image is formed and transferred to a further substrate surface, and that the operations are cyclically repeated.

14. A method according to any of claims 7 to 13, characterised in that the hydrophilic substrate is a planographic plate or roll substrate and the hydrophobic layer is applied in a self-limiting, for example substantially monomolecular, thickness.

15. A method according to any of claims 7 to 13, characterised in that the hydrophilic substrate is a gravure plate or cylinder.

16. A method according to any of claims 7 to 13, characterised in that the hydrophilic substrate is a mesh of substantially hydrophilic material and that the hydrophobic material does not occlude the openings in the mesh.

17. Apparatus for preparing a printing element according to claim 1, characterised by cleaning means

(12-16, 62) for cleaning the surface of a hydrophilic printing element substrate, imaging means (20-30, 20-60, 64-70) for forming a layer of hydrophobic material in an image-related configuration directly on the cleaned surface of the printing element substrate, and a conveyor (10, 90, 97-99) arranged to convey a hydrophilic printing element surface successively past all the said devices.

18. Apparatus according to claim 17, characterised in that the imaging means comprises an applicator (20, 64) for applying a substantially uniform layer of hydrophobic material on the cleaned hydrophilic surface, and physical ablation means (26-30, 60, 70) adapted to remove hydrophilic material from an image-related area of the surface of the coated printing element.

19. Apparatus according to claim 17 or 18 for producing a print on a substrate surface to be printed, characterised by an applicator (50) arranged on the path of the conveyor for applying ink to the surface of the image-carrying printing element, impression means (4, 6) for bringing the substrate surface to be printed into contact with the inked printing element, and control means (80) for operating the conveyor and the said devices in a cyclical manner.

20. Apparatus according to any of claims 16 to 18, characterised in that the conveyor is a printing roll, or cylinder (10), the periphery of which either constitutes or carries (11) the hydrophilic printing element substrate, and the said devices are arranged in succession around the periphery of the roll or cylinder.

21. Apparatus according to any of claims 17 to 19, characterised in that the printing element substrate is a hydrophilic screen mesh (92, 110), mounted on a

cylindrical frame (90) and supported for rotation on rollers (97, 99).

22. Apparatus according to claim 18 characterised in that the physical ablation means comprises an electrical spark discharge device (30), laser (60) or heated fluid jet.

23. A printing apparatus comprising:

- (a) a hydrophilic ink image transfer surface;
- (b) cleaning means to render said hydrophilic surface clean and dry;
- (c) means for arranging a hydrophobic and oleophilic layer of material over said surface in an image-related configuration to form a latent image on said surface;
- (d) means for forming an ink image corresponding to said latent image;
- (e) means for transferring said ink image to a substrate surface;
- (f) means for bringing the transfer surface into operable association with means (b), (c), (d) and (e); and
- (g) means for controlling the operation and actuation of each of the above said means in a desired mode of cyclic operation.

24. A method for automatically printing sequentially a first and a second full-sized image on a substrate surface using an image-carrying printing surface having a single printing surface, comprising the steps of:

- (a) providing the printing surface with a substantially clean surface composed of a first material which is intrinsically substantially hydrophilic;
- (b) forming a first latent image by arranging a thin layer of a second material in a first image-related configuration in direct contact with said surface to provide hydrophobic and oleophilic areas which define

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said latent image over said printing surface;

(c) forming a first ink image, correlating with said first latent image, over said printing surface;

(d) positioning a first substrate surface in operative relationship with said ink image carried by said printing surface;

(e) transferring said ink image from said printing surface onto said first substrate surface;

(f) cleaning said printing surface carrying said ink image and exposing thereby said intrinsically substantially hydrophilic material;

(g) forming a second latent image on said printing surface by arranging another thin layer of said second material in direct contact with said surface in a second configuration, to provide hydrophobic and oleophilic areas which define said second latent image over said printing surface;

(h) forming a second ink image, correlating with said second latent image, over said printing surface;

(i) positioning a second substrate surface in operative relationship with said second ink image carried by said printing surface; and

(j) transferring said ink image from said printing surface to said second substrate surface; and

(k) automatically moving said printing surface through steps (b) to (j) while repeating steps (c), (d) and (e), and steps (h), (i) and (j) as often as desired.

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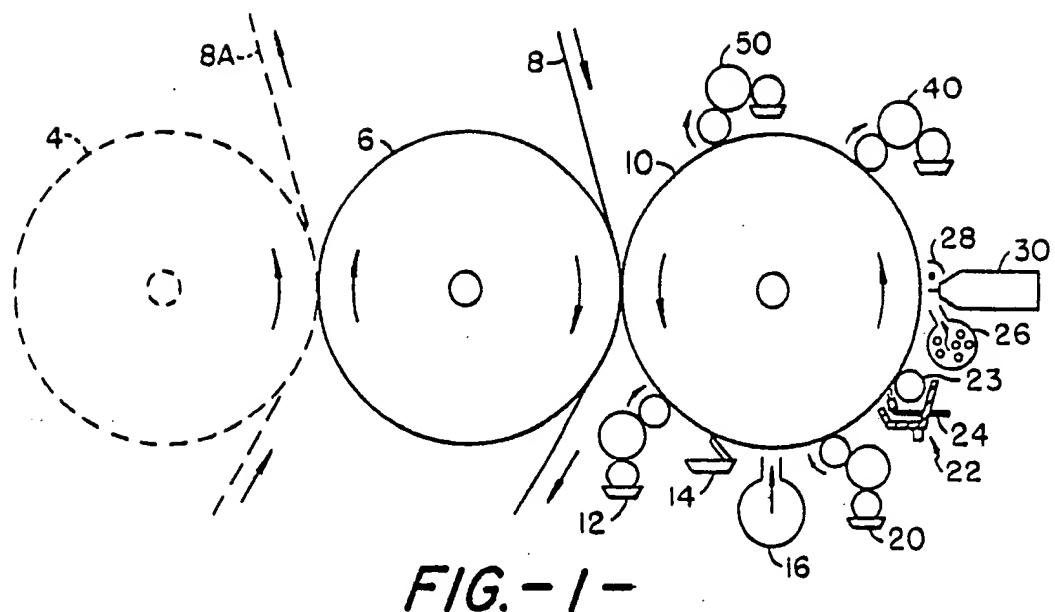


FIG. - 1 -

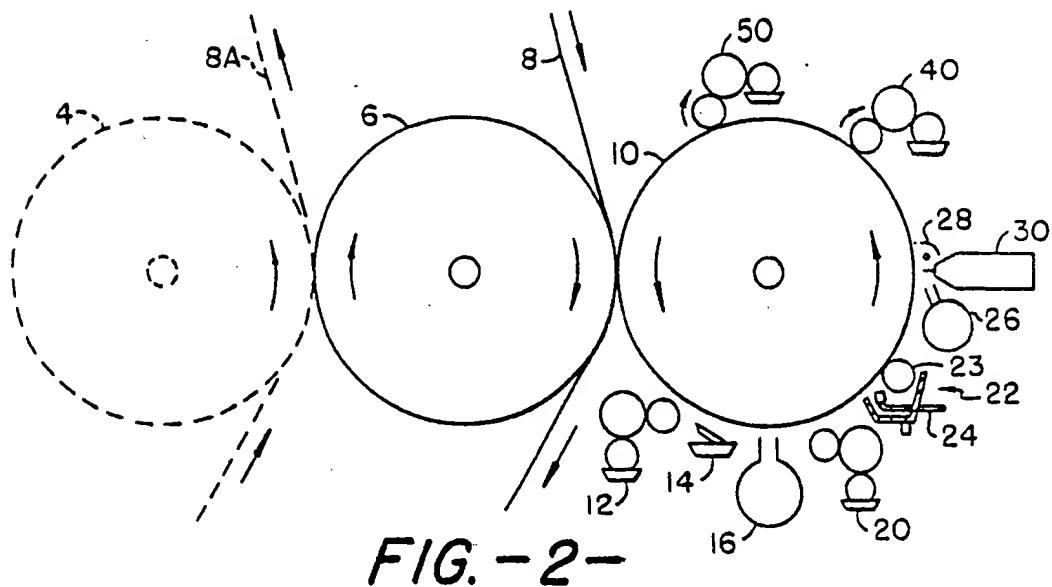


FIG. - 2 -

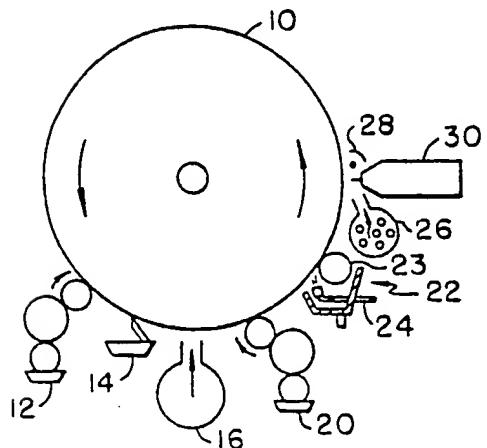


FIG. - 3 -

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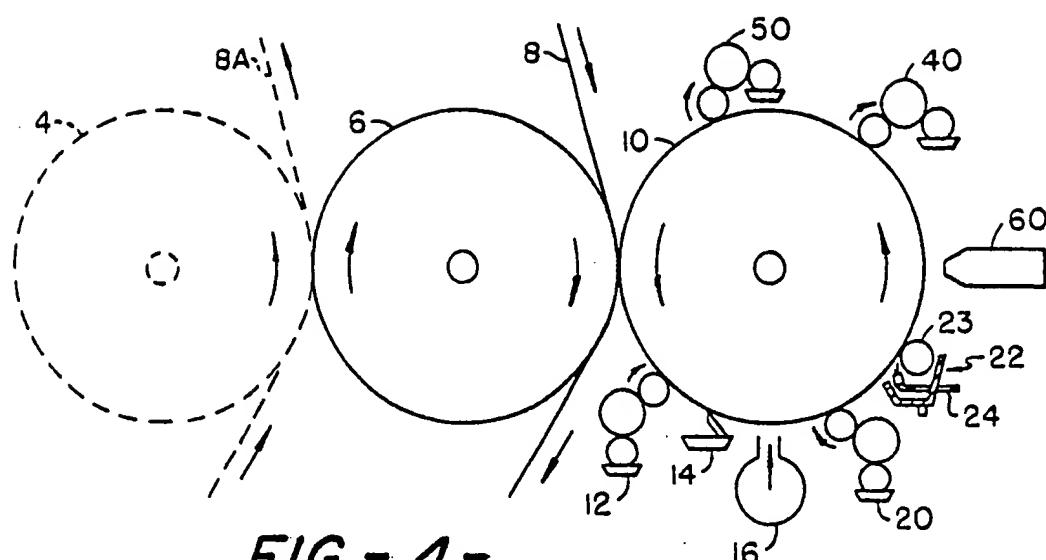


FIG. - 4 -

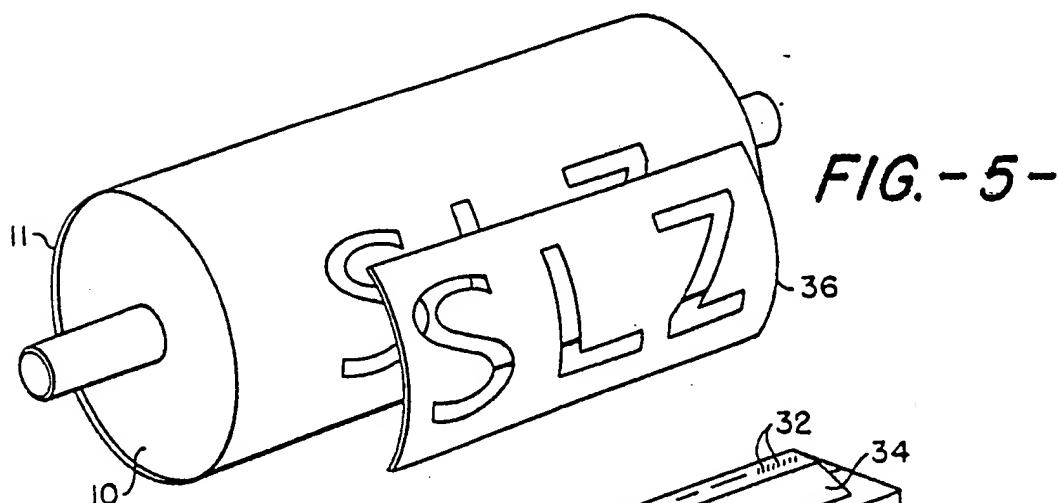


FIG. - 5 -

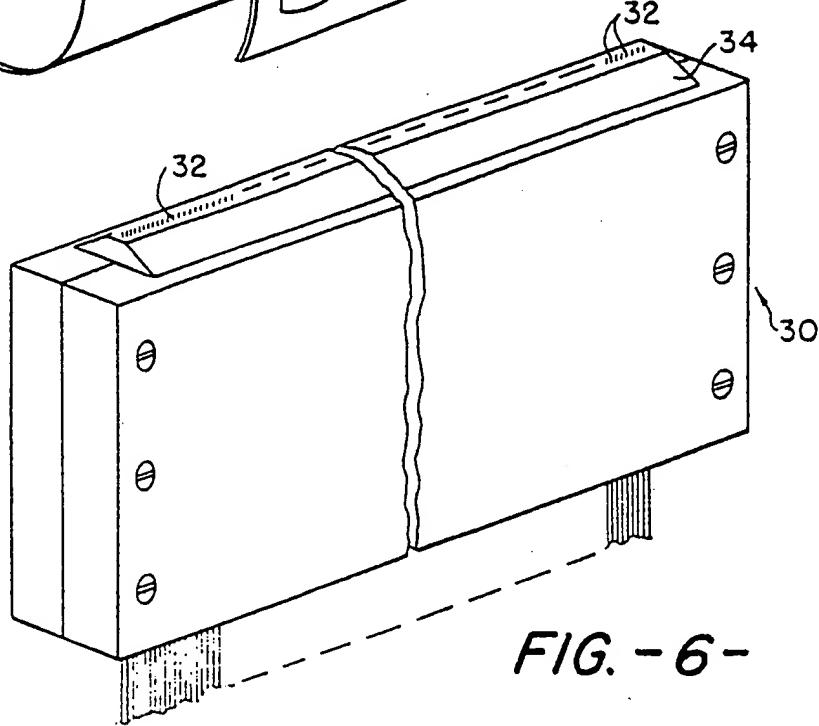


FIG. - 6 -

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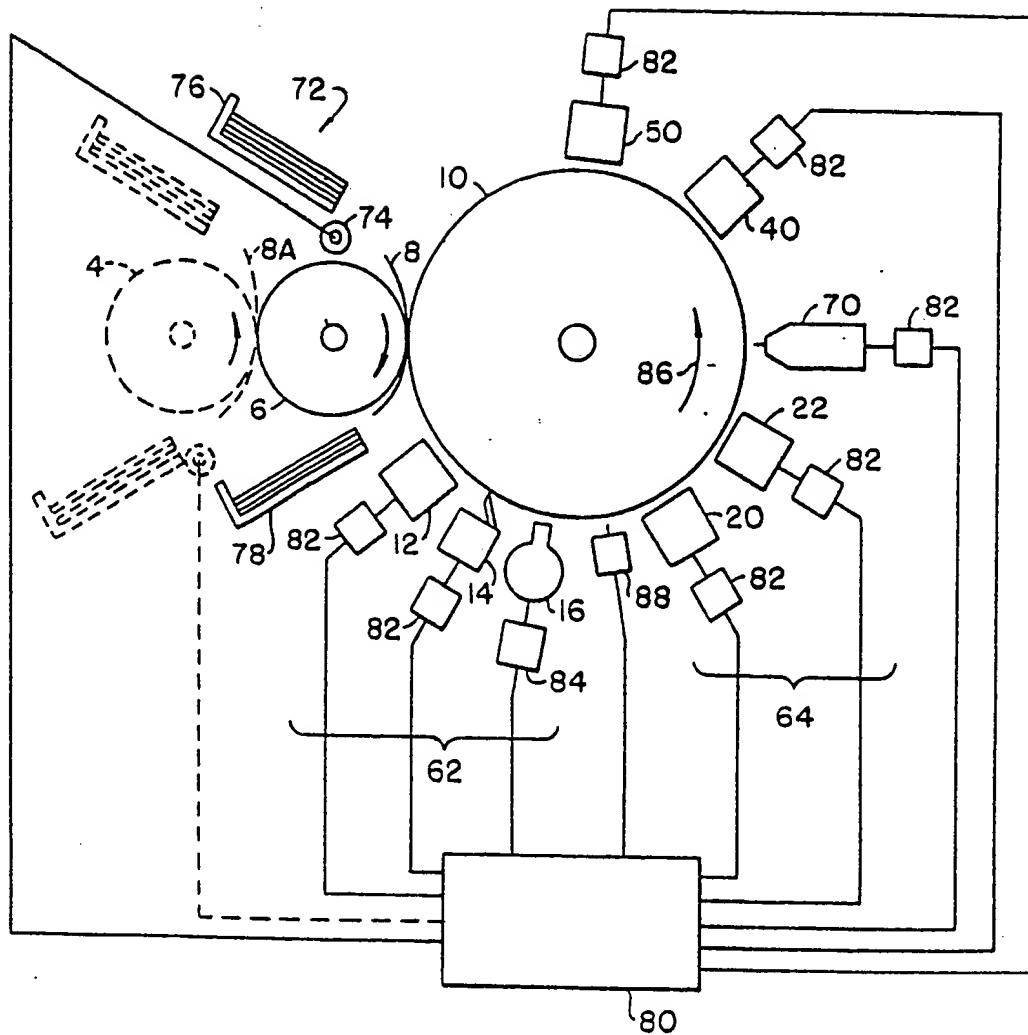


FIG. - 7 -

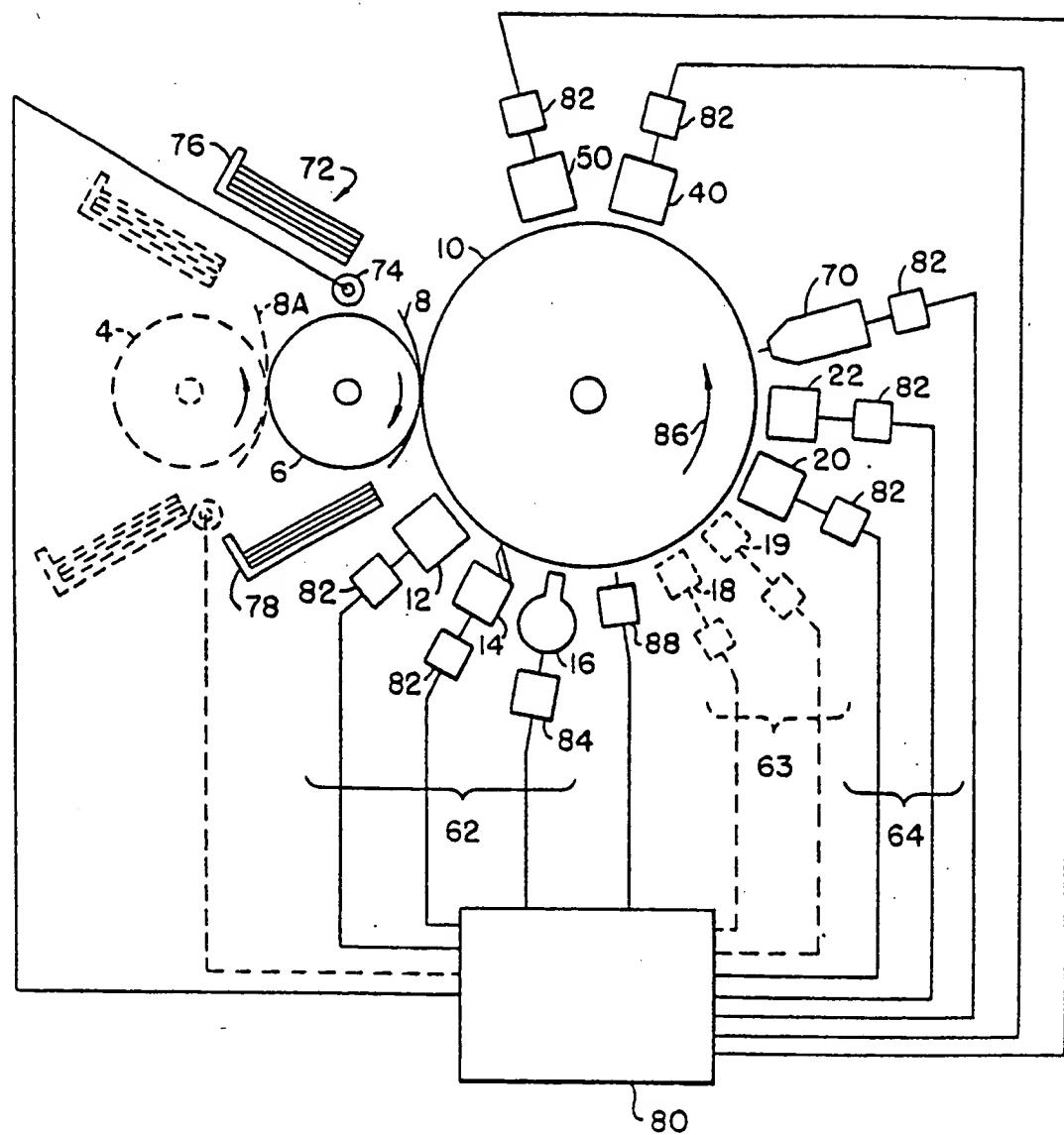
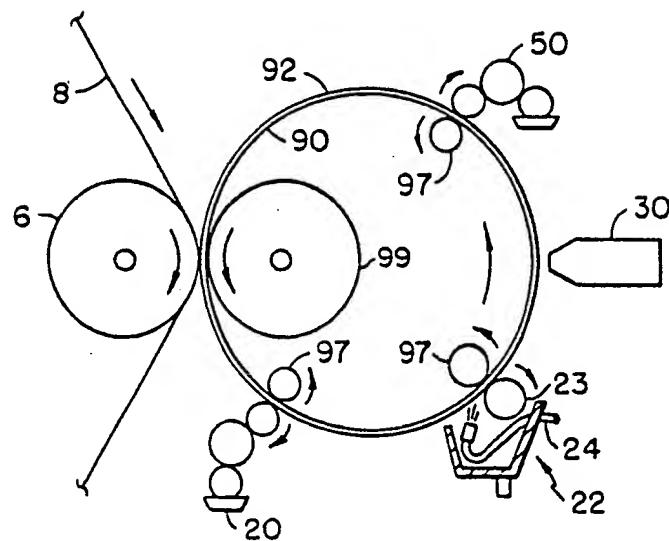


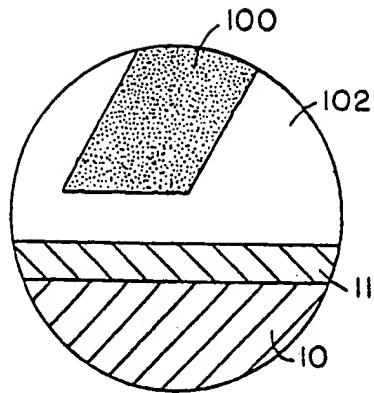
FIG. - 8 -

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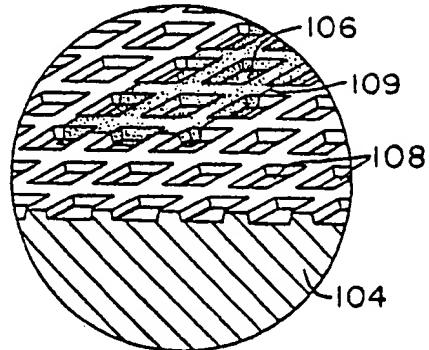
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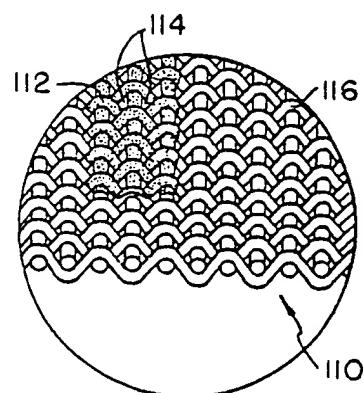
*FIG. - 9 -*



*FIG. - 10 -*



*FIG. - 11 -*



*FIG. - 12 -*

**ANHANG ZUM EUROPÄISCHEN RECHERCHENBERICHT  
ÜBER DIE EUROPÄISCHE PATENTANMELDUNG NR.**

EP 97 10 0579

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten europäischen Recherchenbericht angeführten Patentdokumente angegeben.

Die Angaben über die Familienmitglieder entsprechen dem Stand der Datei des Europäischen Patentamts am  
Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

18-12-1997

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
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Europäisches  
Patentamt

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Nummer der Anmeldung

EP 97 10 0579

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EINSCHLÄGIGE DOKUMENTE									
Kategorie	Kennzeichnung des Dokuments mit Angabe, soweit erforderlich, der maßgeblichen Teile	Betreff Anspruch	KLASSIFIKATION DER ANMELDUNG (Int.Cl.6)						
D,A	EP 0 099 264 A (VICKERS PLC) * Seite 5, Zeile 23 - Zeile 25; Ansprüche; Abbildung 1 *		B41C1/10						
A	EP 0 101 266 A (MILLIKEN RES CORP) * Seite 36, Zeile 22 - Seite 37, Zeile 26 * * Seite 48, Zeile 4 - Zeile 20 * * Seite 69, Zeile 8 - Zeile 16; Beispiel 3 * * Seite 74, Zeile 21 - Zeile 25 * * Ansprüche 8,13,24 *		RECHERCHIERTE SACHGEBiete (Int.Cl.6)						
			B41C						
<p>Der vorliegende Recherchenbericht wurde für alle Patentansprüche erstellt</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Recherchenart</td> <td style="width: 33%;">Abschlußdatum der Recherche</td> <td style="width: 34%;">Prüfer</td> </tr> <tr> <td>DEN HAAG</td> <td>18.Dezember 1997</td> <td>Philosoph, L</td> </tr> </table> <p><b>KATEGORIE DER GENANNTEN DOKUMENTE</b></p> <p>X : von besonderer Bedeutung allein betrachtet  Y : von besonderer Bedeutung in Verbindung mit einer anderen Veröffentlichung derselben Kategorie  A : technologischer Hintergrund  O : nichtschriftliche Offenbarung  P : Zwischenliteratur</p> <p>T : der Erfindung zugrunde liegende Theorien oder Grundsätze  E : älteres Patentdokument, das jedoch erst am oder nach dem Anmeldedatum veröffentlicht worden ist  D : in der Anmeldung angeführtes Dokument  L : aus anderen Gründen angeführtes Dokument  &amp; : Mitglied der gleichen Patentfamilie, übereinstimmendes Dokument</p>				Recherchenart	Abschlußdatum der Recherche	Prüfer	DEN HAAG	18.Dezember 1997	Philosoph, L
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